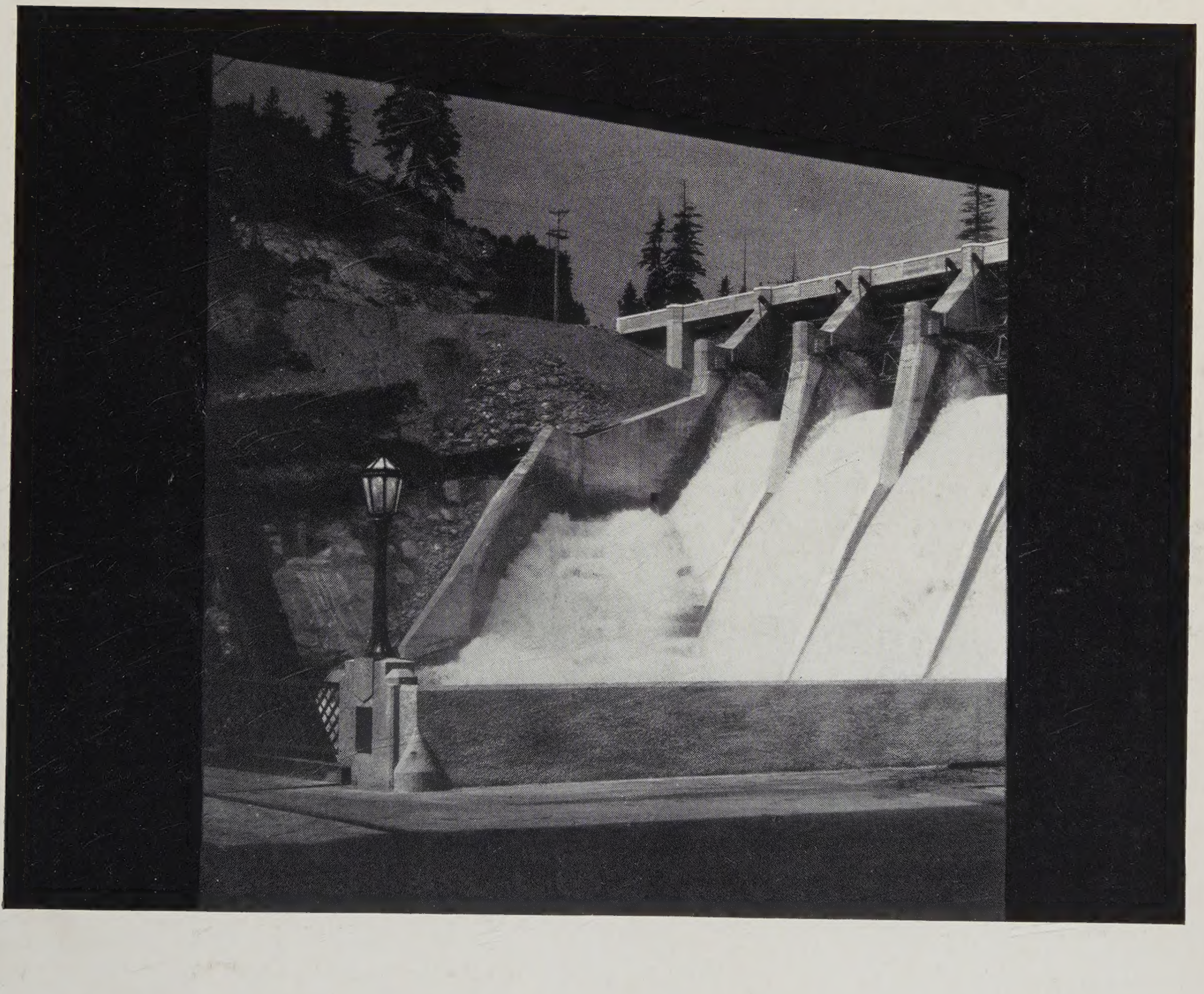
Electrical Engineering

August
1932



Published Monthly by the
American Institute of Electrical Engineers

Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
Vancouver, B. C.	Aug. 30-Sept. 2, 1932	Pacific Coast Convention	(Closed)
Baltimore, Md.	October 10-13, 1932	District Meeting	(Closed)
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	Oct. 23, 1932
Schenectady, N. Y.	May 1933	District Meeting	Feb. 1933
Chicago, Ill.	June 25-30, 1933	Summer Convention	March 25, 1933

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Assn. for the Advancement of Science, Annual convention	Atlantic City, N. J.	Dec. 27–31	C. F. Roos, Permanent Secy., Smithsonian Inst., Washington, D. C.
American Gas Association annual convention	Atlantic City, N. J.	Oct. 10	C. W. Berghorn, Secy., Mfgrs. Sec., 420 Lexington Ave., New York, N. Y.
American Physical Society	Chicago, Ill.	Nov. 25–26	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Physical Society	Pasadena, Calif.	Dec. 16–17	L. B. Loeb, Pacific Coast Secy., Univ. of California, Berkeley, Calif.
American Physical Society annual meeting	Atlantic City, N. J.	Dec. 28–30	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Society of Civil Engineers, fall meeting	Atlantic City, N. J	Oct. 5–8	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Society of Mech. Engrs., annual meeting	New York, N. Y.	Dec. 5–9	C. W. Rice, Secy., 29 W. 39th St., New York, N. Y.
Electrical Insulation Committee, N. R. C., Annual meeting	Baltimore, Md.	Oct. 10–11	Dr. J. B. Whitehead, Johns Hopkins Univ., Baltimore, Md.
Empire State Gas and Electric Assn.	Saranac Lake, N. Y.	Sept. 22–23	C. H. B. Chapin, Grand Central Terminal, New York, N. Y.
Illuminating Engineering Society	Swampscott, Mass.	Sept 26–Oct. 1	E. H. Hobbie, 29 W. 39th St., New York, N. Y.
International Assn. of Electragists	Kansas City, Mo.	Oct. 10–12	L. W. Davis, 420 Lexington Ave., New York, N. Y.
N.E.L.A. Rocky Mountain Div., annual meeting	Estes Park, Colo.	Sept. 12–14	G. E. Lewis, Managing Dir., 366 Gas and Elec. Bldg., Denver, Colo.
National Safety Council annual safety congress	Washington, D. C.	Oct. 3–7	W. J. McCarter, Secy., The Cleveland Railway Co., Cleveland, Ohio
Pennsylvania Electric Assn.	Bedford Springs, Pa.	Sept. 7–9	H. A. Buch, Telegraph Bldg., Harrisburg, Pa.

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This Month—

Front Cover

Spillway as seen through the main doorway of the British Columbia Power Corporation's new Ruskin hydroelectric plant near Vancouver, B. C. Those attending the forthcoming Pacific Coast convention will have opportunity to visit this and other interesting plants.

—Turn to Next Page

THE PROXIMITY effect may be utilized to control the path of electric current used for heating where it is desired that the heating be confined to predetermined strips of the conducting bodies. *p. 559–562*

PRIVATE-WIRE teletypewriter service provides the speed, accuracy, and wide coverage necessary in the communication facilities of the modern police system. Several statewide networks now are in use. *p. 550–553*

A VOLTAGE LIMITING gap for protecting power station apparatus has been developed, the breakdown characteristics of which can be varied over a wide range so as to conform to the characteristics of the station insulation. *p. 579–582*

FIELD observations of conductor vibration on electric power transmission lines substantiate the results of laboratory investigations. Results show that adequate practical protection can be provided by armor rods or dampers. *p. 562–568*

A 3,000-KW sectionalized mercury arc rectifier has been found by tests to have an efficiency one per cent higher than that of the conventional single unit type. *p. 576–579*

MAN'S RETREAT from light into darkness and from ventilated atmosphere to stagnant air is exacting its penalty. So says a medical authority in the twelfth article in the Engineering Foundation's Symposium, "Has Man Benefited by Engineering Progress?" *p. 553–555*

ULTRA precise practical timekeepers of today are of one of 2 classes, depending upon whether the restoring force is gravity as in pendulum clocks, or elasticity as in quartz crystal oscillators. The latter type is a development of recent years and has progressed so that the constancy of rate is comparable with that of the best pendulum clock. *p. 542–549*

ECONOMIC factors are important these days, especially where they concern one's own pocketbook. Members planning to attend the A.I.E.E. Pacific Coast convention August 30 to September 2, 1932, in Vancouver, B. C., may be attracted by the reduced entertainment fees and the exchange rate between Canadian and U.S. currency that at present favors U.S. currency if the exchange be made at a bank. *p. 588.* Abstracts of technical papers scheduled for presentation are published in this issue. *p. 583–586*

COLORFUL pictures of Baltimore, Md., and its attractions for those attending the A.I.E.E. Middle Eastern District meeting, to be held in that city October 10–13, 1932, are presented in a preview written by a member of the local convention committee. *p. 587*

IMPORTANT discussions of papers presented during the Institute's recent summer convention at Cleveland, Ohio, June 20–24, 1932, have been summarized. *p. 590–595*

EDUCATION has been the subject of a number of recent papers presented before the Institute. One of these papers analyzes the various electrical and related subjects in the program for electrical engineering in a number of technical institutions. *p. 568–571*

INTEREST in the "Letters to the Editor" columns of ELECTRICAL ENGINEERING is growing rapidly. These contributions take many forms. Responses which have been received indicate that these letters are widely read. *p. 597–599*

A TENTATIVE standard for engineering abbreviations has been adopted by the sectional committee on scientific and engineering symbols and abbreviations of the American Standards Association. This tentative standard is strictly an editorial specification. The terms most commonly used in electrical engineering literature are presented in this issue. *p. 589–590*

To Members of the Institute—

IN ASSUMING the duties as your president, I welcome the opportunity afforded through Electrical Engineering to express my deep appreciation of the honor you have conferred upon me and to say a few words concerning the activities of the Institute for the coming year.

We are passing through a most difficult period and if we were to approach the year ahead with the least hesitancy or lack of confidence, we most certainly would not make the progress which has been so characteristic of the Institute in past years. However, we do not lack confidence as to the future; we recognize that we have but paused in a forward movement toward even greater technical and professional achievements. If we recognize this period, therefore, as a golden opportunity to consolidate our forces and build an even better organization for the future opportunities so definitely ahead of us, I am sure that we will not only carry on with still greater benefit to each other and to society as a whole, but also we will establish an even higher esteem in the mind of the public as to the importance and value of our profession.

We have but to look back a relatively few years to realize the remarkable advances that have been made in a short span of time in all phases of the arts and sciences with which we are concerned. Not a day passes without new vistas opening before us and revealing the way to new opportunities which cannot but lead to further material improvements and social advancements. Occasionally we hear the question raised as to whether scientific research and the general extension of engineering knowledge are not proceeding too rapidly for the common good, and consequently by some process might better perhaps be retarded. Aside from the impracticability of such considerations—touching as they do on man's curiosity about the unknown, or the stopping of the flow of new things which man believes to be valuable additions to social life—those who have given these matters serious study realize that the problem centers not in the products of science, but rather in the fact that our knowledge as to the proper use of the results of our scientific advancements has not developed nearly as rapidly as have the products of our research and engineering activities. These are matters which we of the Institute who are concerned in one way or another with the fundamental or applied sciences must consider. Our opportunity lies before us in the chance to help to bring about the effective general understanding of these matters that seems so necessary.

Not only in those things of which I have spoken, but likewise in the general solution of the problems which confront the world at large at the present time, there is urgent need for the help of individuals trained to discover facts and able to turn our efforts in the directions which such facts indicate. By basic training and practical experience, the engineer is indeed qualified to assist in just such a challenging task, and I am confident that we shall find him taking an ever greater and greater part, in full cooperation with others, in finding the solution of the serious problems confronting our nation and the world in general.

It seems to me, therefore, that we are in an era when the problems of the engineering profession are undergoing some rather important changes in their fundamental aspects, but in spite of our present temporary difficulties, I believe that these very changes, as well as other factors, all point to further progress and opportunity for those of our profession.

Within the Institute itself, this next year naturally will present many difficult problems and we should be prepared to shape its policies and procedures to conform to the times and conditions as encountered. Financial matters will require most careful consideration to the end that, while maintaining the financial integrity of the organization, we may as far as practicable continue the essential services to our members. I bespeak your hearty support of the headquarters and committee personnel faced with this and other important problems incident to these trying times, including the difficult questions involved in the Institute's publication services.

To our committees and the activities of our Sections we look, as in the past, for the spreading of interest and the enhancement of the value of our society to our members. At no time in Institute history have the activities of these groups been more important than at present, when it is hoped that we may not only hold together our great organization to as nearly as possible its full membership, but also add to its strength and solidarity.

Always of the greatest value, but now of more than usual importance, I believe, are the activities of our Student Branches. The problems confronting our younger members are more than usually difficult at this time, and it is hoped that the cooperation between our Sections and Branches may be fostered to an even greater and more effective degree than in the past. Such contacts must inevitably result in mutual encouragement, and benefit not only our student members but also our older members.

As for myself, my service in the Institute long has been one of my greatest pleasures, and I welcome with keen anticipation the new opportunities which will be afforded me as your president to break down the barriers that distance creates for us, visiting again the various Sections, and through professional as well as personal contact have the privilege of carrying on with you the important activities which we shall find in hand during the coming year.

PRESIDENT

Modern Developments in Precision Timekeepers

Clocks of the gravity or pendulum type have for many years been used as precision timekeepers; but through recent refinements they have been made more accurate and reliable. Another development of the last decade is the use of the elasticity of quartz crystal oscillators as the restoring force in precision timekeepers; this has been made possible by the vacuum tube and associated electrical circuits. Both types of timekeepers are discussed in this article.

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At THE BEGINNING of the present century it was believed by many that the limit of accuracy attainable by mechanical clocks had been reached. This presumption was based on the performance of specific mechanisms which had indeed been brought to a high state of perfection, but this presumption did not allow for the possibility of other types of mechanism for measuring time or for certain refinements which since then have more than doubled the accuracy and reliability of the best clocks then available.

As the words clock, chronometer, etc., have come to have definite technical meanings in the art, the more general term "timekeeper," will be used. In the broadest sense a timekeeper may be defined as any physical means that can be used for the subdivision of time into intervals known in terms of a standard time interval. Thus, any periodic phenomenon can be adopted in a timekeeper provided its period can be recorded in terms of another. In this sense the earth and the moon are timekeepers, as are vibrating pendulums, tuning forks, and other sustained oscillators.

As all man-made timekeepers are essentially "oscillators" consideration will first be given the equation of motion of a simple oscillator which can be expressed as $M\ddot{x} + R\dot{x} + Sx = A \sin(\omega t + \phi)$ where M corresponds to the mass, R to the resistance or damping and S to restoring force proportional to displacement x. The right hand term represents the sustaining force required on account of the dissipation of energy in the oscillator. For an oscillator to be a perfect timekeeper, all of the quantities, M, R, S, A, and ϕ, must remain invariable. While M and S are the chief rate governing quantities, the others from a design point of view are the most difficult to control.

Essentially full text of "Modern Developments in Precision Clocks" (No. 32-52) presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932.

The ultra precise practical timekeepers of today may all be contained within 2 classes, depending upon where S (the restoring force) is

1. Gravity (as in pendulum clocks)
2. Elasticity (as in quartz crystal oscillators)

The second class is a development of the last decade and was made possible by the development of the vacuum tube and associated electrical circuits. Intercomparisons between timekeepers of the 2 classes provide a most valuable means for the study of changes in gravity and related phenomena. These 2 classes are discussed separately.

Gravity Timekeepers

Unfortunately the motion of a pendulum is not quite simple harmonic motion since the restoring force varies as the sine of the angular displacement (instead of directly as the displacement) and therefore the period is not truly independent of the amplitude. This can be seen from the equation of motion of the pendulum which in its simplest form, neglecting damping and sustaining forces, is

$$Ml\ddot{\theta} + Mg \sin \theta = 0$$

The free period T for any given angular displacement can be expressed by the series:

$$T = 2\pi\sqrt{\frac{l}{g}}\,(1 + 0.0625\,\alpha^2 + 0.00358\,\alpha^4 + \ldots)$$

where α is the maximum deflection from midswing expressed in radians. The corresponding change in rate expressed in seconds per day is shown in the curve, Fig. 1. Various attempts have been made to construct pendulums having a period independent of arc, but mechanisms to accomplish this result always have introduced larger irregularities than those which they attempted to cure. Practical design has been confined to keeping the amplitude small and to providing a governing action so that any slight increase in amplitude causes an opposing tendency to decrease the amplitude, or *vice versa.*

The old anchor recoil escapement accomplished this by increasing the friction on the pendulum with

ncrease of amplitude. The inertia escapement in he Shortt clock attains a similar result without the erious disadvantage of introducing friction. This nertia escapement is based on the principle that a veight rolling down an inclined plane applies a reater horizontal force to a slowly moving plane than o a faster moving one. A suitable inclined plane atached to a pendulum receives an amount of energy oughly inversely proportional to the amplitude, or to he velocity at midswing. As the amplitude increases, the energy delivered into the system becomes ess. But in spite of these controls the amplitude loes vary in fact, which at the present time probably ccounts for more irregularities than any other facor. Dr. J. Jackson has shown that if the daily mplitude is regularly recorded and the clock rate orrected accordingly, a number of the irregularities n the Shortt clocks at Greenwich can be explained.

If a direct amplitude control could be applied to a lock, such corrections should not be necessary. Such method is now being tried on a Shortt clock in the Loomis Laboratory. When the amplitude of the pendulum exceeds a predetermined amount by even).0001 in., a signal is sent, via a pointed electrode which hangs in the evacuated pendulum casing, to a vacuum tube which operates a relay, so that the next 30-sec. driving impulse is omitted. The electrode is so adjusted that about every fifth impulse is omitted n this way. With this control the constancy of rate appears to be improved, but at least a year's record is needed for conclusive proof, as the variations which his device seeks to control usually only occur at intervals of several months.

The complete solution for the period of a pendulum swinging in a resisting medium, such as air, involves a actor $\sqrt{1 + kR^2}$ where R is the resistance to motion and k is a constant depending on the structure of the pendulum and the nature of the drive. Although it would appear from this that all pendulums should be operated in a high vacuum, practically it has been found that, from the standpoint of stability of period with pressure variation, the most satisfactory pressure for the Shortt clock is about 15 to 20 mm. of mercury. When the pressure is very low or at zero, the arc when not definitely controlled is very unstable and causes large changes in rate; but in the neighborhood of 15 mm. of pressure there is a stabilizing action due to the air friction, and a neutralization of the following four effects of pressure variation:

1. Change in the restoring force due to buoyancy of the pendulum n air.
2. Change of center of gravity due to buoyancy when the pendulum s made of dissimilar materials.
3. Change of effective mass due to air carried along by the pendulum.
4. Change of friction and consequent change in arc.

The first and fourth are probably of greatest importance. With decrease in pressure the first decreases the period and the fourth increases it. At the critical pressure the 2 effects are about equal and opposite. In the determination of gravity, where very precise pendulums are used, all of these factors must be considered carefully.

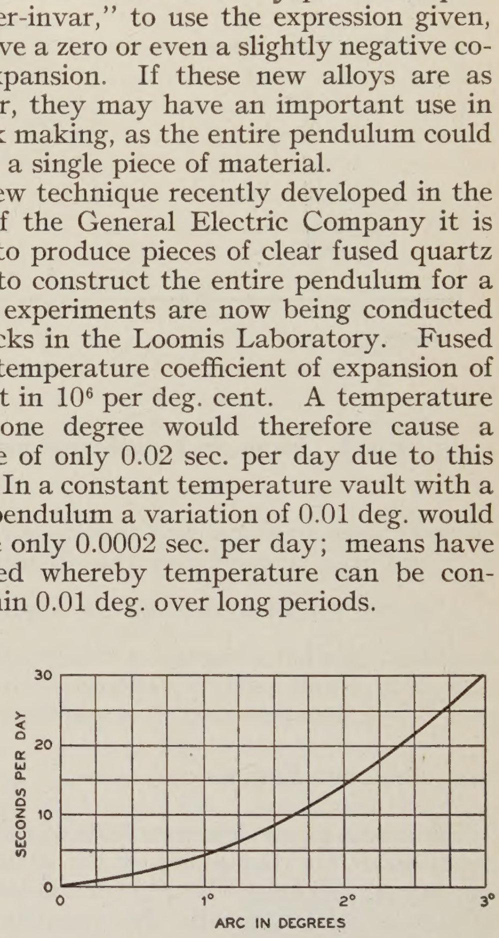
When the amplitude control device previously described is used, the pressure can be reduced to a small fraction of a millimeter, which thereby reduces the effect of friction to a minimum. The term $\sqrt{1 + kR^2}$ then becomes practically unity and the required sustaining energy can be very much reduced.

Variations in Inertia

Because of its effect on inertia, the expansion of the pendulum with temperature must either be reduced or compensated for. At the present time practically all clocks of high precision employ invar pendulum rods with bobs of type metal or invar. The bob rests on an expansion collar, the dimensions of which are calculated to compensate for the lengthening of the rod. Some recent studies in Japan have produced a "super-invar," to use the expression given, which may have a zero or even a slightly negative coefficient of expansion. If these new alloys are as stable as invar, they may have an important use in precision clock making, as the entire pendulum could be made from a single piece of material.

With the new technique recently developed in the laboratories of the General Electric Company it is now possible to produce pieces of clear fused quartz large enough to construct the entire pendulum for a clock. Some experiments are now being conducted with such clocks in the Loomis Laboratory. Fused quartz has a temperature coefficient of expansion of about 0.5 part in 10^6 per deg. cent. A temperature variation of one degree would therefore cause a change in rate of only 0.02 sec. per day due to this effect alone. In a constant temperature vault with a fused quartz pendulum a variation of 0.01 deg. would affect the rate only 0.0002 sec. per day; means have been developed whereby temperature can be controlled to within 0.01 deg. over long periods.

Fig. 1. Change of rate of pendulum with semi-arc, expressed in seconds lost per day



There are 2 other major effects which should be considered in connection with pendulum length. These are (1) variations in the position of the point of oscillation, and (2) the instability of materials with time, in other words, aging. The effect of knife edge wear on the period of an ordinary pendulum is appreciable. A wearing of 0.001 mm. will change the rate of a seconds pendulum nearly 0.1 sec. per day. Largely for this reason, a flexible spring suspension of elinvar[4] is used in most precision clocks. But even the spring is suspected of changes in length, and, what is just as bad, also of variation in stiffness which would change the point of flexure and the restoring force. Aging effects in the pendulum rod can be reduced only by finding better materials. It may be that fused quartz or possibly some large single crystal

will be found finally to be the most suitable material to use.

The effect of knife edge wear on the period of a pendulum in theory can be avoided almost entirely by suspending the pendulum at a distance from its center of mass equal to the radius of gyration about that point. This simple principle of mechanics has of course long been recognized and experiments are being conducted in Germany[6] and elsewhere to determine its value in a precision timekeeper. In the case of a uniform straight rod this distance should be $\frac{1}{2\sqrt{3}}$ of the total length from the center. With this condition fulfilled a change in this length due to knife edge wear of one part in a thousand would affect the period less than one part in a million.

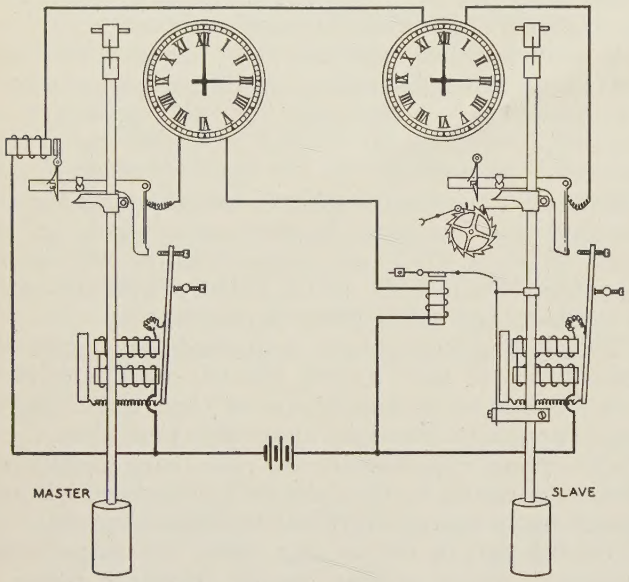


Fig. 2. Shortt clock mechanism and circuit

The Driving Force

The terms on the left-hand side of the fundamental equation at the beginning of the article have been considered briefly. The right-hand term—the driving force—and especially the quantity ϕ, the phase angle, which presents perhaps the most difficult problem in the design of all timekeepers, will now be considered.

The impulse should be delivered to the pendulum at the time when the velocity is at maximum; that is, at the center of the swing, in order to reduce to a minimum the effect of variations in the driving force upon the rate. If the impulse is applied before the instant of maximum velocity, the rate is increased momentarily. If the impulse is applied after the instant of maximum velocity the reverse is true. Of course the impulse actually is of finite duration and the desired effect is approximated by supplying the pulse symmetrically with respect to the instant of maximum velocity, thereby tending to neutralize the acceleration and retardation effects. The necessity for this method of applying sustaining power pulses to a pendulum has been realized almost from the beginning of precision clock history but cannot be overemphasized.

The 3 clocks most often recognized as precision timekeepers are the Leroy, Riefler, and Shortt. One or more of these is to be found in most of the important time laboratories and astronomical observatories throughout the world. In the Shortt clock the impulse to the master pendulum is controlled by means of an auxiliary or "slave" pendulum which in turn is automatically synchronized with the master pendulum to within ± 0.003 sec. at all times. The means by which this is accomplished can be seen from Fig. 2 which shows the master and slave pendulums with all the essential control elements, and the counting or time indicating dials. Although the master pendulum determines the rate of the system, the slave pendulum and associated mechanism does the work of releasing the driving pulses at the proper time. The slave pendulum, through a jeweled ratchet and pawl-operated count wheel, releases mechanically a weight arm once each 30 sec. at just the right time so that a small wheel on the gravity lever, rolling down a curved inclined track associated with the slave pendulum rod, imparts the sustaining impulse to it. As soon as the mechanical impulse is delivered, this arm closes an electrical contact which resets the weight arm before the return swing of the pendulum, in readiness for the next 30-sec. impulse. The current which resets the slave clock drive also releases the impulse mechanism for the master clock thereby avoiding the use of any mechanical connection with the master pendulum other than that of the impulse wheel. As in the case of the slave drive mechanism, the impulse lever makes an electrical contact after delivering its impulse to the master pendulum, which resets the gravity arm and in addition operates the "hit and miss" synchronizer on the slave clock. The slave pendulum normally runs a little slower than the master and is speeded up when necessary by means of a spring attached to the pendulum rod which is engaged by the synchronizer whenever the slave lags

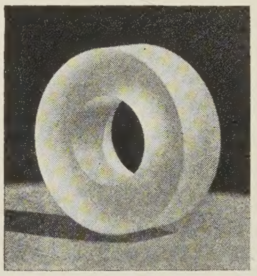


Fig. 3. (Above) Quartz crystal with zero temperature coefficient used in crystal clock

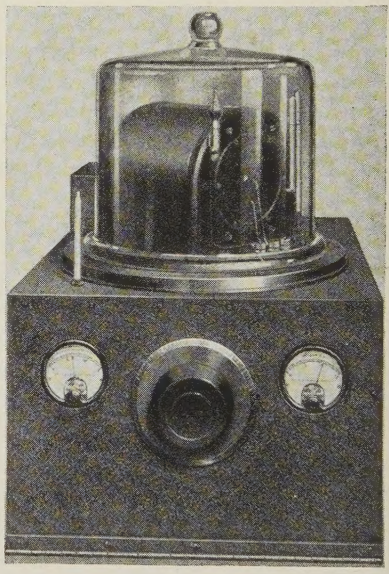


Fig. 4. (Right) Complete 100,000-cycle quartz oscillator

by more than 0.002 sec. behind a definite phase relation to the master.

There are reasons to believe, however, that small changes in phase do occur, especially with variations in amplitude. Probably future improvements in gravity timekeepers will include improved methods for keeping the phase of the driving force more nearly constant.

Crystal Oscillators as Timekeepers

Within recent years developments in methods of keeping time have progressed so far that the constancy of rate of certain mechanical resonators, maintained in vibration by vacuum tubes, may be comparable with that of the best pendulum clocks. Such oscillators have the chief attributes of a good clock and can be used to operate or control a wide variety of time mechanisms with even greater versatility than the conventional pendulum.

The most accurate oscillators of this type known to the authors are controlled by plates of quartz crystal vibrating at a high frequency; that is, high in comparison with the frequency of a pendulum. Probably the most accurate of these at the present time is a set of four 100,000-cycle oscillators that has been built by the Bell Telephone Laboratories principally for use as a primary frequency standard. These laboratories also have supplied a similar set of oscillators for the same purpose to the U.S. Bureau of Standards.

In this type of oscillator the frequency is controlled by a ring of quartz crystal as shown in Fig. 3, about 3 in. in outside diameter. The frequency of the oscillator is the same as that of the crystal; that is, 100,000 cycles per second. One complete oscillator including temperature and pressure controlled crystal and shielded vacuum tube circuit is shown in Fig. 4.

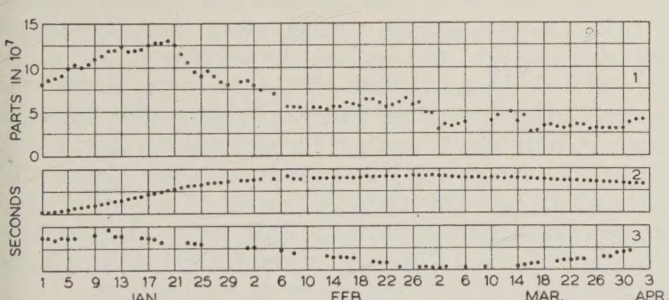


Fig. 5. Performance data for crystal clocks

Curve 1. Rate comparison between crystals 1 and 2
Curve 2. Integral of curve 1, showing running comparison
Curve 3. Indicated time of one crystal clock vs. corrected signals from U.S. Naval Observatory

In order to operate clock mechanisms in the most direct way it is necessary to control from this high frequency another which is low enough to operate a synchronous motor. This is done by an electrical circuit known as a sub-multiple generator which controls one frequency at a definite fraction of another in absolute synchronism. Several types of circuit have been used for this, all of which are as positive in action as a set of gears. Usually the low frequency used to operate the motor is 1,000 cycles. Each pole on the motor in motion therefore corresponds to one millisecond in time; hence, any variation in the motor mechanism or operation can amount at most to a fraction of a millisecond. Such a motor can be used to operate time indicating or measuring apparatus in a wide variety of forms.

As a rate controlling element a crystal of quartz used in this way has a number of outstanding useful properties. As previously discussed, the rate of vibration is controlled chiefly by the effective mass and stiffness of the resonator. On account of the chemical stability of the substance SiO_2 and the physical stability of the crystal structure of quartz these may be expected to be constant to a high degree. At the present time, variations introduced by the vacuum tube circuit and the crystal mounting are such that no conclusive evidence of aging in the quartz has been obtained.

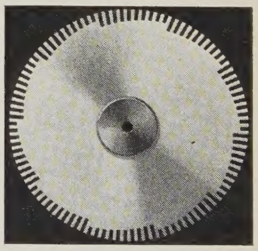
Since the elasticity is a constant for such displacements as are required (amounting to less than one part in 100,000 change of dimensions) the rate is substantially independent of amplitude. The amplitude can be controlled at nearly a constant value, however, by proper adjustment of the vacuum tube circuit.

The temperature coefficient of frequency can be made as near to zero as required at any given operating temperature by properly adjusting the shape of the resonator. Crystals which have been in continuous operation for 3 years have not shown any appreciable change in this adjustment.

Crystals are not affected by gravity or magnetic fields and can be shielded readily from electrostatic fields. They can be mounted so as to be relatively immune to vibrations which always seem to be present in the earth, especially near traveled roads and manufacturing centers. This may be found to be an important factor in the location of accurate clocks in cities or near earthquake zones. The crystals referred to above are mounted on the seventh floor near a much traveled thoroughfare in New York City.

The electromechanical coupling to a crystal for imparting the sustaining energy to it makes use of its piezo activity. As far as has been determined there is no increase in decrement directly due to this means of coupling, although of course through this coupling properties of the electrical circuit such as damping may be manifested in the crystal. The logarithmic decrement of a 100,000-cycle low-coefficient crystal mounted in air at atmospheric pressure and coupled into the electrical driving circuit is about 0.00012.

Fig. 6. Special light interrupter for the production of accurate timing signals by means of a photoelectric cell



Probably the largest rate disturbing factors in the crystal clock at the present time are due to effects of the phase ϕ of the applied driving force. This factor varies slightly with circuit variables, aging of vacuum tubes, and power voltage variations. Developments

now in progress indicate, however, that the effects of these variables can be greatly reduced, and a marked improvement in performance should result. The performance, as clocks, of a pair of crystals is shown for a 3-month period in Fig. 5.

While the crystal clock assembly is more costly than a pendulum clock and requires more elaborate associated electrical equipment, it is believed for many purposes to be decidedly superior because of its great versatility. For example, its rate can be adjusted at will over a sufficient range to allow for such aging effects as occur. Also, the phase, or indicated time, can be adjusted with extreme accuracy. This can be done most advantageously in the electrical circuit by means of a phase shifter which operates continuously through 360 electrical deg., or any fraction or multiple thereof. If used in the 100,000-cycle circuit, one complete turn of the dial corresponds to a final adjustment of 0.00001 sec., which obviously is greater accuracy than needed in any ordinary time mechanism.

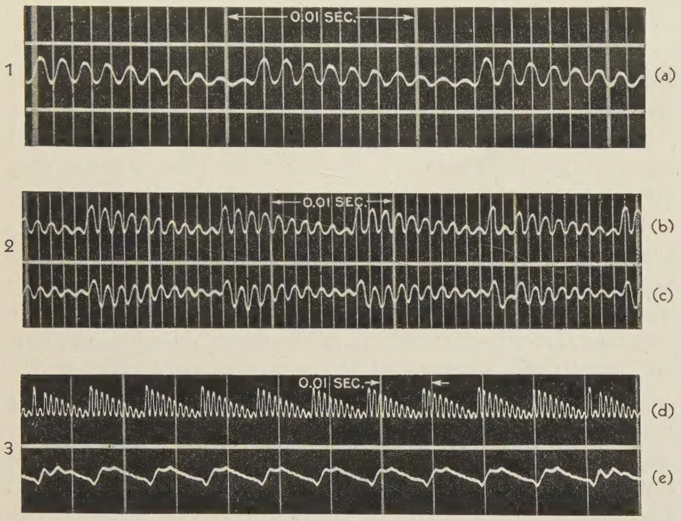


Fig. 7. Oscillograms of time signals produced by photo-electric cell method

Oscillogram 1. Direct signal (a) obtained from photoelectric cell

Oscillogram 2. Direct signal (b); and (c) the same signal transmitted by radio. A method is indicated for marking every 0.1 sec.

Oscillogram 3. Direct signal (d); and (e) same signal rectified for recording with only 0.01-sec. resolution

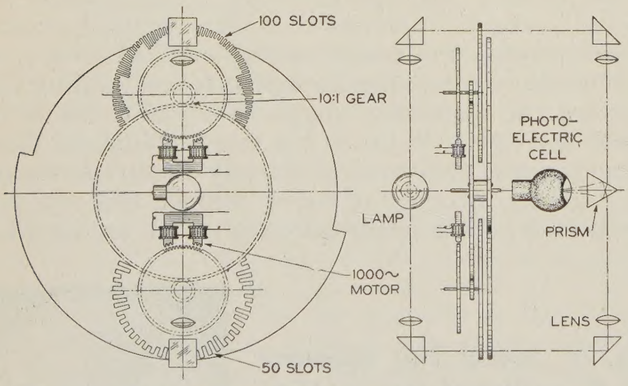


Fig. 8. Proposed method for production of accurate time signals by photoelectric cells

The accuracy of inter-comparison of crystal clocks may be very high. An absolute comparison accurate to better than 0.00001 sec. can be maintained continuously, while under special conditions short time comparisons accurate to one part in 10^{10} can be made. This high accuracy of comparison is due chiefly to the large number of vibrations per second, 200,000 times greater than with a "seconds" pendulum. Even greater accuracy of comparison could be obtained by the use of higher frequency crystals, but for reasons of convenience and greater freedom from the effect of external circuits and the mounting, the lower frequency is preferred.

One application of considerable interest is that 2 clock mechanisms can be operated from the same crystal control in this way so that one keeps true mean solar time when the other keeps true sidereal time.[9] It can be shown readily that any ratio of rates can be obtained for such a purpose accurate to at least one part in 10^{10} without the use of an unduly complicated mechanism. Lord Grimthorp has shown why a pendulum cannot be used for this purpose, but his reasons do not apply to the crystal control method.

By means of a photoelectric cell and a shutter of the type shown in Fig. 6, signals of extreme accuracy can be controlled which could be used for radio transmission of time signals or for any purpose requiring great accuracy. When this disk is rotated at 10 revolutions per second by a crystal controlled motor the current from the photoelectric cell is 1,000 cycles modulated in the manner indicated in oscillogram 1 of Fig. 7, at 100 cycles per second. By marking one 0.01-sec. element, as for example by partially blocking one sector, a positive 0.1-sec. indication is obtained. The oscillograms shown in Fig. 7 were made with the disk shown, and indicate how with the use of a suitable oscillograph, a continuous time signal can be recorded that can be read to a fraction of a millisecond. This resolution would be very useful for accurate time measurement work, for studies in radio propagation times, and for measurements of gravity. Observers requiring less resolution than this could obtain 0.01-sec. accuracy by the use of a rectifier and a recorder accurate to only 0.01 sec. The same is true for 0.1 and 1.0-sec. accuracy by a suitable choice of transmitting disk and receiving equipment.

The second oscillogram shows the signal direct from the disk and after it had gone through a complete radio transmitter and receiver consisting of a total of 11 tandem vacuum tube stages and associated equipment. As indicated, the total delay encountered was about 0.1 millisec., and the distortion is not appreciable. Of course any combination of make and break signals can be controlled in this way using either a continuous or a modulated tone. If desired a series of $^1/_2$-sec. dashes could be controlled, interspaced by a dot-dash code to designate each dash.

A complete time signal control mechanism based upon this idea is shown diagrammatically in Fig. 8. In the method shown, light from a straight filament lamp is imaged on the slotted edge of a disk driven at 10 revolutions per second by a 1,000-cycle motor. The light entering the photoelectric cell is modulated

as indicated, at 1,000 times and 500 times per second alternately, and controls a corresponding electrical signal. The slow speed shutter, rotating at one revolution per second, causes the effective light path to alternate between the 2 disks once each second, and gives a corresponding variation of electrical signal. This signal can be used for any resolution from one second down to one millisecond and can be received through static and fading. It can be reduced to the dash-space type by the use of a simple voice-frequency filter to suppress the undesired half signal, or used as a continuous signal for oscillograph recording.

Among the advantages of the crystal clock should be mentioned that in order to control any number of clock mechanisms with the same precision it is necessary only to distribute the constant frequency current derived from the crystal to the separate mechanisms. This can be done on any scale economically feasible.

Experiments in Time at Loomis Laboratory

The clock installation at the Loomis Laboratory, Tuxedo Park, in brief consists of 3 Shortt clocks mounted in an especially favorable location practically free from traffic and electrical disturbances, and carefully temperature controlled. The excellence of the location is enhanced by the fact that the clock vault is excavated in the solid rock of the mountain on which the laboratory stands, and the 3 massive masonry piers for mounting the clocks are effectively a part of this rock. One of the 3 Shortt master pendulums in its casing is shown in Fig. 9 mounted on its pier within the temperature controlled vault.

By means of the Loomis chronograph[3] it has been possible for the first time to obtain a running phase comparison of a number of clocks with great precision. Prof. E. W. Brown and Dr. Dirk Brouwer have shown[10] that the probable error of the mean hourly rates as measured by this chronograph is less than 0.0001 sec. With a resolution of this order, it is possible to study some effects that would be forever unsuspected with the use of any comparison equipment used heretofore.

The rate curves on Fig. 10 will illustrate a case in point. These 3 curves show the differences in rates between the 3 Shortt clocks taken in cyclic order, plotted on a very open scale over a period of about 3 months. Although the mean rates over this and much longer periods are constant to one part in ten million, there are fluctuations in rate having for the most part perfectly definite periods. These fluctuations are real and a study[10] of the data by Professor Brown showed that the periods correspond to the differences in periods of the pendulums taken in pairs. This implies that there is coupling between the pendulums and that the rate of one is modulated by that of the others even though the pendulums swing practically in vacuum and are mounted on separate massive piers, and that they swing in planes 120 deg. apart. This would seem to show that massive as the piers have been made, they are not infinite in comparison with the 14-lb. pendulums, and that strains set up by each pendulum are felt in some degree by the others through the piers and solid bed rock.

A study was made of the performance of several actual installations of precision clocks, including Riefler clocks nos. 60, 70, and 151 at the U. S. Naval Observatory, Washington, D. C.; Riefler clock no. 412 and Shortt clock no. 29 at the Dominion Observatory, Ottawa, Can.; Shortt clock no. 11 at the Royal Observatory, Greenwich, Eng.; Leroy clock no. 1,185 at the Paris Observatory, Paris, France; and Shortt

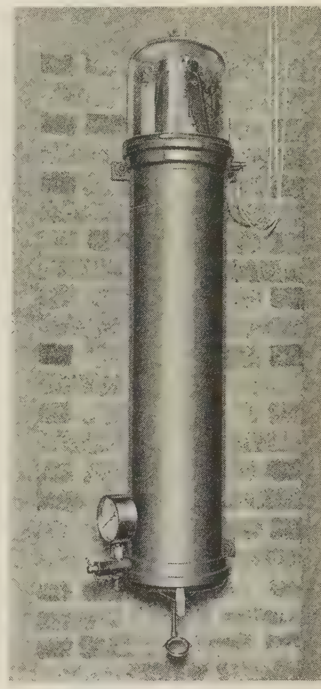
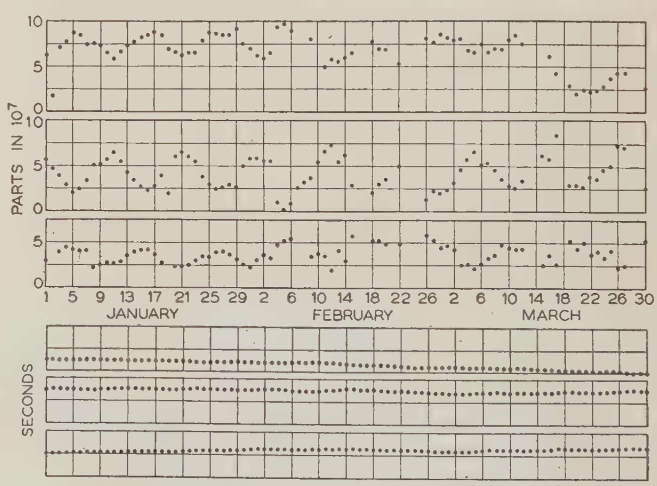


Fig. 9. (Right) Master pendulum in casing for one of 3 Shortt clocks located in the Loomis Laboratory

Fig. 10. (Below) Intercomparison of 3 Shortt clocks which are located in the Loomis Laboratory

Rates are given in the 3 upper curves. Integrated rates are given in the 3 lower curves



clock no. O at the Royal Observatory, Edinburgh, Scotland. This study showed that although the rate variations of the 3 Shortt clocks at the Loomis Laboratory are quite appreciable as measured by the Loomis chronograph, the relative performance, as clocks, is all that could be desired, and indicates that factors having small but real effects upon the rate can be detected by a chronograph with this high resolving power when they would not be observed at all by ordinary methods. The 3 rate curves and the 3 time curves of Fig. 10 are plotted to the same scale as the corresponding crystal data in Fig. 5.

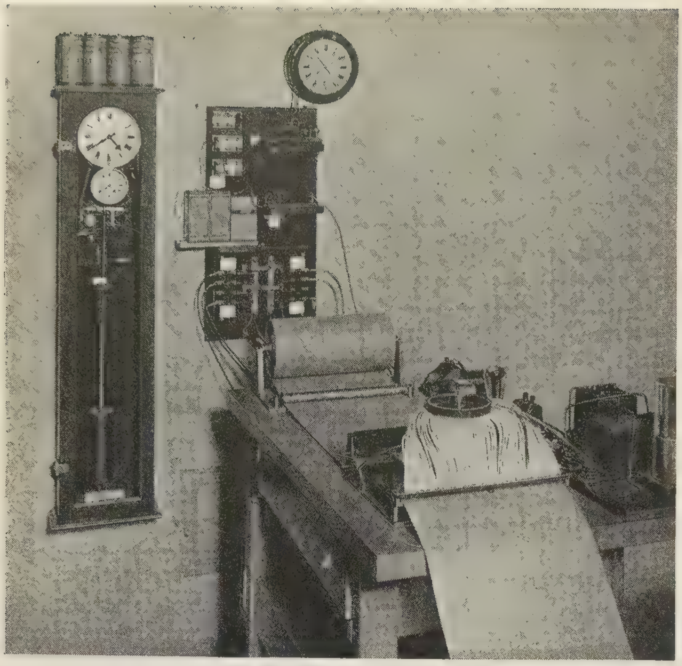


Fig. 11. Loomis chronograph and one of 3 Shortt slave clocks in the Loomis Laboratory

The Loomis chronograph shown in operation in Fig. 11 consists of the following essential parts:

1. A strip of paper about 10 in. wide moving at a uniform rate between a long grounded electrode and a comb consisting of 100 separate equally spaced pointed electrodes.
2. A distributor having 100 segments separately connected to the 100 elements of the comb, operated at exactly 10 revolutions per second by a synchronous motor from a source of 1,000-cycle current.
3. A source of high potential consisting of an induction coil through the primary of which a large condenser is discharged when a record is to be made. A small condenser on the induction coil secondary stores sufficient energy to produce an intense spark of very short duration.
4. A single relay in the common circuit of all the time devices to be recorded on the moving paper strip.

If the relay is operated every time the distributor makes some exact whole number of revolutions a series of perforations will be made in a line parallel with the edge of the paper. If in the time between sparks, the motor revolves a whole number of times plus or minus 100, successive perforations will be displaced an amount corresponding to one millisecond in time. One second in time is represented by 10 complete transits of the chart, so that, in effect, the chart is 100 in. wide and the effective recording element moves at the rate of 500 ft. per min. Thus from the slope of the line of perforations with respect to the edge of the paper the difference between the rate of the distributor and the rate of the sparks can be determined with high precision. Similarly any number of separate sets of sparks can be recorded simultaneously on the same chart, using the same actuating relay and distributor. The relative rates may be determined by measuring the difference of slopes of the rows of perforations.

This is the method used for intercomparing the 3 Shortt clocks and for comparing them with crystal oscillators in New York City. To accomplish this, 1,000-cycle current controlled by the Bell Laboratories' crystal is sent over a private wire to Tuxedo and there used to drive the distributor as outlined above. The resulting records are continuous comparisons of the 3 Shortt clocks and the crystal, accurate to better than one millisecond in time.

Since the crystal does not respond to variations in gravity while the pendulum does, the difference in rates contains a term having the period of the lunar day, corresponding to the direct gravitation effect of the moon on the pendulums. Several months' records of the Loomis chronograph have been analyzed[10] by Professor Brown and Doctor Brouwer and a lunar term observed having the proper period and magnitude. A graph of the lunar effect derived in this way is reproduced from their paper in Fig. 12. The periodic gain and loss in indicated time is about 0.0002 sec. per lunar day.

The results of time studies obtained at the Loomis Laboratory have been very encouraging and it is planned to continue the researches in clocks and time measurement methods.

Possible Future Investigations

No doubt there is a practical limit to the accuracy attainable in a timekeeper but as long as random changes in rate are observed which cannot be explained by uncontrollable properties of matter (such as Brownian movement) that limit has not been reached, even with the types of mechanism at present in use.

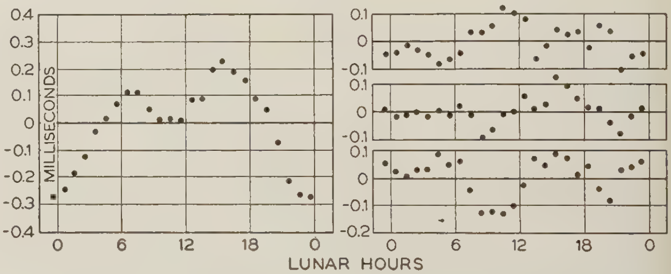


Fig. 12. Analysis of comparison data between crystal clock and 3 pendulum clocks revealed the periodic lunar day variation shown in the left hand curve

The suggestion has been made of utilizing the constant velocity of light between fixed points as a measure of period. At present the velocity of light is known to less than one part in a million. Even if it were known with greater accuracy, the practical difficulties of establishing such a standard, except in a very rough way, would be insuperable. In the first place the distance between the measuring points would have to be known to one part in a million, that is, better than 0.06 in. in a mile, assuming no other error, to define a standard good to only 0.1 sec. per day. Considering the difficulties in measurement, an accuracy of a little better than a part in a million is about all that could be expected of such a method by any means now known.

The extreme definition of some spectral lines indicates a very slightly damped oscillation of some sort in the atom, and some thought has been directed to means of making a frequency comparison between

these vibrations and others of lower frequency that could be used to measure time as previously outlined. The effective logarithmic decrement of the "oscillator" behind the red line of cadmium can be estimated as about one tenth of that of a quartz resonator. The difficulties of utilizing this sort of thing as a time (or frequency) standard are: First, it is not known at present whether the "frequency" of an atomic disturbance has the same physical significance as vibrations-per-second and, second, even if the significance were the same, the orders of the 2 frequency ranges are so far separated that no means known at present could be used to effect the comparison. Besides, the energy of a spectrum line is no doubt made up of a large number of damped wave trains superposed in some fortuitous fashion as would cover the identity of separate cycles.

Probably the real final limit in the accuracy of timekeepers is concerned with the measure of our time standards. Some observations indicate that the rate of the earth's rotation is not constant, but that there are both systematic and apparently random changes in rate as compared with the motion of other astronomical bodies believed to be more stable. For example: About 1918 a rather abrupt change in rate was observed which amounts to about one part in thirty million. This is small to be sure, but points to the improbability that the rate of any phenomenon is absolutely constant. After all, time is relative and the most nearly accurate measure of time must always be in terms of the most nearly constant motion that can be observed.

At the present time in the official observatories of the various countries the usual procedure is to plot the star observations in terms of their master clock and then to draw a smooth curve, which curve is adopted as the official clock correction. To some extent the drawing of this curve is a matter of judgment, based partly on the number and certainty of the star observations and partly on the estimated performance of the master clock in terms of their other clocks. These observatories at the present time also transmit and record radio time signals and publish periodically corrections to these signals in terms of their "standard clock error." From these data alone it is not possible for any one observatory to compare its clocks directly with the clocks in another observatory. If the observatories would publish one additional number for each of their important clocks, namely, the comparison of each clock with their official time, it would be possible to compare the rates of the clocks in such observatory directly with clocks anywhere else in the world where the radio time signals can be received. This would involve only a very small amount of additional work as the numerical data have to be obtained in any case. It is well to note in this connection that the United States Naval Observatory has adopted a procedure which is very similar to this, the only difference being that instead of publishing the corrections to each of its principal clocks, it publishes a single number which represents the correction of the weighted mean of several clocks. This is an excellent beginning and it is hoped in the interest of future clock developments and of studies in gravity and related phenomena, that others will follow.

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Near the scene of the A.I.E.E. 1932 Pacific Coast convention, the Second Narrows, Vancouver, B. C.

Here 2 34.6-kv. lines and 2 communication circuits of the British Columbia Electric Railway Company, Ltd., cross Burrard Inlet; the crossing is designed to carry ultimately 2 165-kv. lines, 4 34.6 kv. lines, and 4 communication circuits. Length of the main span is 1,641.5 ft.; minimum height above high water, 186 ft. Conductors on main towers and back guys on anchor towers ride on sheaves

Communication by Police Teletypewriters

Police organizations throughout the country rapidly are adopting the teletypewriter, the latest development in record communication. By this means alarms are typed at one point and simultaneously recorded in printed form at a large number of widely scattered stations. The engineering of facilities required for a modern police system involves the solution of many special problems.

BY
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New York, N. Y.

Fig. 1. Teletypewriter installation at the headquarters of Troop K, New York state police, at Hawthorne

Fig. 2. Traffic on the teletypewriter system of the Pennsylvania state police, in number of messages per month

SPEED, accuracy, and wide coverage are important factors in the communication facilities of any modern police system. During the past 2 years there has been a definite and rapid adoption of private wire teletypewriter systems by the police as a means of communication between the different units within a police organization. The teletypewriter provides means for typing a message at one point and recording the message in typewritten form at a distant point as well as at the home station. These systems are now so widespread that approximately 40 per cent of the people of the United States live in areas protected by police teletypewriter systems.

The primary use of the teletypewriter by the police is to broadcast alarms, usually consisting of notices to apprehend suspects, watch for missing persons, or recover stolen goods. Teletypewriter systems also find a large field of usefulness in the handling of routine correspondence between units of the larger police organizations.

The different types of traffic handled on a typical police system are shown in Table I. These statistics were obtained from the Pennsylvania state police system covering the month of October 1931. The statewide broadcast includes messages from Harrisburg to each of the 110 municipal police stations throughout the state. It will be noted that more than 50 per cent of the statewide broadcasts had to do with stolen automobiles. Since these communications usually involve registration numbers and proper names, the printed record is an important factor in eliminating errors. The rapid growth in the amount of traffic handled by this system since it was established in January 1930 is indicated in Fig. 2.

General Features

Briefly, the teletypewriter, or printer as it is sometimes called, is a machine which allows a message to be typed simultaneously in 2 or more remote locations. The connections between the various machines on a given network usually consist of ordinary telegraph circuits. If they are long, it may be necessary to provide terminal and intermediate telegraph repeaters in order to obtain satisfactory teletypewriter transmission.

In general, the teletypewriters as used for police communication are arranged to print the received message in page form. The typical machines of this type are shown in Fig. 1. It will be noted that some of the machines are equipped with keyboards while others are for receiving only, and therefore have no keyboards. Power for operating the various mechanisms is provided by fractional horsepower motors which take their current from the local a-c. or d-c. lighting circuits.

The layout of the private wire teletypewriter system of the New York state police is shown in Fig. 3. In this network there are at present 85 teletypewriter stations, 64 of which are arranged for both sending and receiving while 21 are equipped for receiving only. There are 6 switchboards located at the headquarters of the various state police troops. All but one of these switchboards are located in police barracks outside of metropolitan areas. The telegraph circuits involved in this network total about 3,500 miles and require 80 telegraph

Based upon "Police Teletypewriter Communication" (No. 32M8) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

repeaters. Fig. 4 shows a typical telegraph office where provision is made for maintenance and supervision of such private wire systems. The circuit mileage is made up of various types of telegraph facilities, including the voice frequency carrier telegraph system, the metallic telegraph system, 2-path polar and one-way polar system, the polar duplex and the neutral system.

Technical Features

The essential elements of the teletypewriter system are: the sending mechanism, the telegraph line, and the receiving teletypewriter. By means of the sending mechanism, manually selected characters of the alphabet and certain necessary typewriter functions, such as paper feeding, carriage returning, and spacing, are converted into groups of electric impulses. These are transmitted over the telegraph circuit by means of different current values, which, as in practically all land line telegraph circuits, are of 2 values. (One of these current values may be zero as in the neutral telegraph system.) The signals set up the selecting devices in the receiving machine corresponding to the transmitted character, and cause this character to be reproduced.

The selecting code which is used employs 5 signal elements for each character. This 5-unit code, in combination with the possibility of either of 2 current values for each unit, provides 32 possible combinations. For instance, representing the 2 current values by (1) and (2) one of the 32 possible combinations would be 1-2-2-2-2. That is, the first unit would be transmitted at one current value and 4 following would be transmitted with the other current value. Another combination would be 1-2-2-2-1, etc.

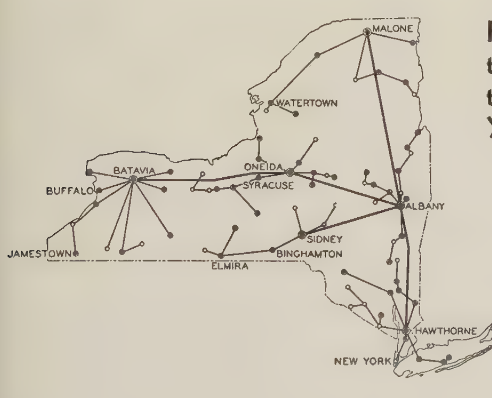

Fig. 3. Teletypewriter system of the New York state police

Table I—Traffic on a Typical Police System in One Month

Type of Alarm	Statewide Broadcast	Local Harrisburg Zone Broadcast
Wanted for crime	207	136
Stolen automobiles	1,254	0
Other stolen property	36	10
Missing persons	146	42
Arrests of wanted	39	38
Miscellaneous	99	543
Recovered automobiles	700	0
Requests for information	0	614
Total	2,481	1,383

One of the 5 unit combinations is assigned to each of the 26 letters of the alphabet, leaving 6 remaining for the teletypewriter functions, such as spacing, carriage returning, and paper feeding. Numerals and punctuation marks are obtained by providing 2 characters on each type-bar of the printing mechanism as in an ordinary typewriter, and one code combination is used for shifting from one set of characters to the other. The remaining, or 32nd, selecting combination is employed to allow a receiving station to "break" or stop the sending operator when that station wishes to send.

It of course is necessary to identify each of the 5 successive signal elements at the receiving end, in order that the proper selection be made. This is accomplished by having the receiving mechanism run in synchronism with the sending mechanism. This synchronizing is accomplished without unduly complicated mechanism, by means of the so-called start-stop principle which may be described briefly as follows:

The sending and receiving mechanisms each are driven by fractional horsepower motors running at approximately the same speed, the speeds being controlled either by governors or by the use of synchronous motors. These motors run continuously while the teletypewriters are in use, and through friction clutches drive the transmitting and receiving mechanisms. The transmitting and receiving mechanisms are restrained from operating, however, by mechanical arrangements which are released when the first line signal is received. In order to accomplish this starting function, the 5 selecting signal elements are preceded by a signal element of a current value opposite to that of the line in the idle condition. The receipt of this first signal at the receiving teletypewriter starts the printing cycle. The 5 selecting elements which follow the starting signal select the proper character and cause it to be printed. Following the selecting impulses a seventh signal element is transmitted over the line which causes the receiving mechanism to stop at the completion of the printing cycle. When the next group of signals is received, this cycle is

Fig. 4. Typical repeater office for private wire teletypewriter systems

repeated. With this arrangement the receiving mechanism does not start until the first impulse is received, and stops at the completion of the cycle. Therefore, the sending and receiving mechanisms are required to remain in synchronism for one printing cycle only. The teletypewriters usually are arranged to type at 60 words per min., or 6 letters per sec. The duration of a printing cycle, therefore, is approximately $^1/_6$ sec., and synchronism is accomplished without rigid requirements on the speeds of the teletypewriter motors.

In addition to simplifying the manner of maintaining synchronism, the start-stop principle makes it possible for 2 stations to communicate without regard to the distance between them or to the lag introduced in the telegraph signals by intervening circuits or apparatus. The selecting signal elements are always transmitted and received in the same time relation to the start impulse which controls the start of the printing cycle.

Special Features

Police teletypewriter systems have presented a number of special problems. One of these is due to the fact that the communications are of an intermittent nature, but service must be available continuously. It is therefore desirable that the calling station be able to start and stop the motors of all of the distant called stations. Therefore most police machines are so equipped that starting is accomplished by the sending of a "break" signal and stopping by the sending of a "shift" followed by an "H" signal from the teletypewriter keyboard.

By the use of "shift" signal followed by a letter signal, other features are made available. Teletypewriters thus are regularly provided with a signaling bell. Also in special cases, a loud ringing bell is provided, either a single stroke or a continuous alarm being used.

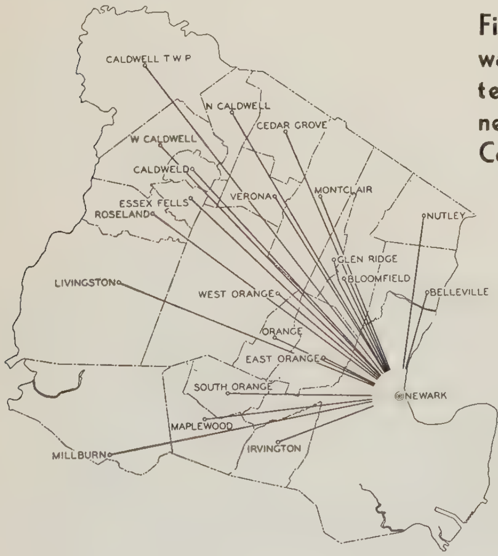

Fig. 5. The one-way fixed layout teletypewriter network in Essex County, N. J.

Some of the switchboards used in police systems are equipped with keys for switching, while others have cords and plugs of the type used in telephone switchboards. Since these switchboards are often located in remote places outside of metropolitan areas, it usually is necessary to provide a complete power plant to supply current for line facilities, supervisory signals, and teletypewriter machines.

In some statewide systems the stations are divided into zones, with each zone under the control of an individual switchboard. Arrangements may be provided which allow the operator at general headquarters to take control of the broadcasting circuit for any or all zones throughout the state, thus permitting the statewide broadcasting of certain alarms. The transferring of all the lines from the zone switchboard to sending relays under the control of the circuit from headquarters is accomplished by sending a code signal from a special key at general headquarters over the regular teletypewriter circuit to the zone headquarters. After the statewide broadcast, the circuit may be restored to normal by sending a long "break" signal from headquarters. These operations are accomplished without any action by operators at zone headquarters.

Fig. 6. Teletypewriter installation at New York City police headquarters. Police Commissioner Edward P. Mulrooney is shown dictating a message during a recent 7,000-mile police teletypewriter hook-up covering the United States and Canada

In some of the municipal networks, arrangements have been set up whereby a message or alarm sent to an outlying station equipped with a machine for receiving only, can be acknowledged. Usually, a separate circuit is provided for this purpose so that the operation of an acknowledgment key at the receiving station will give a signal, such as the lighting of a lamp at general headquarters. The attention of the receiving station operator may be attracted at the end of a message by the ringing of the teletypewriter bell at all receiving stations.

In a multi-station series network it sometimes is desirable to be able to select stations individually or in groups. For this purpose a selective calling arrangement using a regular telephone dial is used.

When the code number of a particular station is dialed, a selecting device at the station completes the power circuit, thereby starting the motor of the called station. A visible or audible signal will be operated to attract the attention of the operator at the called station, and a busy signal will be lighted at all other stations indicating that the circuit is busy. When desirable, a lock-out or secrecy feature may be provided which prevents any station not called from starting its machine and receiving the message being transmitted. This system has the obvious disadvantage that only one conversation at a time is possible on the network.

Circuit Layout Features

Various types of circuits are adaptable to police teletypewriter systems. A few of these systems will be described briefly.

The one-way fixed layout system includes a central transmitting point from which communications are transmitted to a number of machines arranged for receiving only. An example of this type of system is shown in Fig. 5. The outstanding advantage of the one-way fixed layout system is the speed with which broadcasts can be made, since the entire network is always available.

The 2-way fixed layout system has all of the stations connected to the circuit so that any 1 can send and the others will receive. The outstanding advantage of this type of system is that the entire network is available to each station for broadcasting alarms or for intercommunication between individual stations. This system has the disadvantage that when 2 stations are communicating, the entire network is not available for a broadcast without interrupting the local conversation.

The one-way selective system consists of lines radiating from a switchboard at general headquarters with machines in the outlying points equipped for receiving only. This is similar to the one-way fixed layout system except that individual lines or groups of lines can be selected.

The 2-way selective switching system can be obtained in either one of 2 methods, or a combination of both. The first method is to provide a central switchboard with lines radiating out to each individual station. The second is to provide more than one station on each line and to have these stations equipped with the selective calling devices mentioned previously. The advantages of this system are similar to those outlined in the 2-way fixed layout system, but the former has the added advantage that more than one conversation at a time can be carried on between stations in the network.

Many of the police teletypewriter systems combine the one-way and the 2-way features. The first statewide police system to be installed is operated by the state police of Pennsylvania and is of this type. Among other systems of this type is the one in New York City. Of this, the teletypewriter room at general police headquarters is shown in Fig. 6. The switchboard, which has direct lines to 33 precinct stations in Manhattan and to 4 others in borough headquarters, may be seen in the background.

Exchange Service

When in November 1931 the telephone company offered teletypewriter exchange service to the public, the police departments of the country were among the first to avail themselves of this type of service. The exchange service provides switchboards and trunk line facilities for interconnecting teletypewriter stations at any place in the country. The police department subscribing to this service is provided with a teletypewriter machine with which it may call a teletypewriter exchange operator and obtain a connection with any other exchange teletypewriter station, whether this station is in the same city or in a distant city. This new service provides a nationwide system for interconnecting the various police departments in the country with the same type of record communication which has been so useful in the private wire systems.

The Effects of Artificial Habits

Views from a medical college dealing with the effects of engineering progress upon human life add another independent voice to the general discussion of benefits. This is the twelfth article in the Engineering Foundation's symposium, "Has Man Benefited by Engineering Progress?"

By
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By BUILDING tents and huts, by covering the body with fur and cloth, primitive man was able to leave the cave, to expand into the open plain, and to survive in a colder climate; then protection against rain, cold, and storm was rendered complete with the invention of glass, which brought with it a new factor—comfort. All of these measures, first protective, then comfort producing, formed a continuous evolution which led to an artificial change of environment: From the straw apron to the modern apparel, from the primitive hut to the

modern apartment house—an evolution which, when expressed biologically and physically, meant but a retreat from light into darkness and from ventilated atmosphere to stagnant air. Prejudices of fashion and custom have but served to fix the results of these developments and to render irreversible this crime against nature, this exclusion of natural stimuli to the skin. The penalty for this transgression is being paid.

Light Starvation Favors Disease

Lack of ultraviolet rays, unless replaced by a high vitamin D diet, leads to rickets, tetany, and other ills, and predisposes strongly to infections, particularly pneumonia. Light starvation favors certain skin diseases, either directly from lack of stimulation or indirectly by breakdown of the vegetative nervous system and the absence of its coordinative action on the various powers of the body.

One important function of the skin is heat regulation. Heat must be conserved as much as possible in a cool environment, and strongly dissipated in a warm atmosphere. A complicated mechanism serves this purpose: Various stimuli from the skin and from the heat center of the brain affect the internal secretion, the blood chemistry, the blood capillaries of the skin and the sweat glands in such fashion that adaptation to the environment takes place. Operation of this mechanism represents a healthful physiological and psychological exercise for the body: It necessitates chemical and physical work; it requires a coordination of the efforts of the whole autonomic apparatus, which includes the nervous systems, the endocrines and the blood vascular system. The perfect working of this whole mechanism determines to a large extent a healthy constitution. By living in closed rooms and by dressing in heavy and tightly fitting garments, we have allowed this mechanism to cease functioning and its branches to degenerate. The result is that we cannot withstand even small variations of temperature, usually reacting with a cold to even the most moderate exposure. It is the fear of such exposure together with the dictates of fashion that have led the stronger sex so to overdress that their bodies constantly move in a tropical climate.

Fashion and Science Conflict

Fashion and science now have reached the point where a break may occur unless fashion gives way. It should not be difficult to design a garment without a narrow collar and a tight belt, so that air ventilation is permitted. Disposing of vest and coat should not carry the stigma of social misdemeanor, but should be permitted as a means to allow the body to cool off, to admit some light and to increase its vitality. So long as our mode of dressing is not improved, I see no advantage in the use of windows made transparent to ultraviolet rays or in the use of ultraviolet lamps.

The great development, in recent times, of the building industry, of transportation, and of communication, with the resulting concentration of individuals within cities, schools, churches, theaters, trains, and street cars, has but served to strengthen the gregarious habit of man; this in itself has been shown by statistics to be the prime cause of the prevalence of infectious and contagious diseases. It is these very diseases which the medical man, the sanitary engineer, and the health director find so difficult to combat. That these effects are being realized is evidenced by the efforts of theater owners toward ventilation and temperature regulation of their theaters, and by the increased tendencies of the people to abandon the narrow confines of the city for the more open territory of the suburb. These tendencies have been abetted by the privacy and quickness of the automobile and by the comfort of the radio, together with coming television.

The invention of the machine, followed by its constant modification and improvement to meet the various needs of today, has increased a hundred fold the means for comfort and lessened human labor, and has been heralded as a welcome means to lighten the burden of man. But now the pendulum having swung in the prophesied direction, we have gone from the frying pan into the fire; from the dilemma of too much work we have entered into the morass of idleness. The politician of today has failed to find a remedy for this situation, so let us turn to the views of the biologist.

Views of a Biologist

In his book, "Studies on Human Biology," Pearl devotes one chapter to the influence of physical activity upon mortality. He bases his deductions on English statistics on the mortality of occupied males more than 15 yr. of age. He divides the 132 occupations into indoor and outdoor work and each of these into 5 groups of increasing activities, from light to hard work. After discussing and eliminating most of the possible sources of error he comes to the following conclusions:

1. Light, medium, and heavy work cause no difference of the death rate between the ages of 15 and about 45 yr. From 45 yr. on, however, hard work increases the death rate, with a strongly increasing ratio for the higher ages. This makes it evident that "before age 40 is attained, it makes no difference in the rate of mortality, whether the occupation involves light or heavy physical labor. After about age 45 it appears that a man shortens his life by definite amounts in proportion as he performs physically heavy labor."

2. Mortality is distinctly lower for outdoor than for indoor workers. This indicates the superior healthfulness of outdoor life.

I should like to add a few generally accepted premises upon which to base a few suggestions of an important social bearing:

1. Work is healthful, mentally and physically, for men and women between 17 and about 45 yr.

2. Many modern professions require too much sedentary life and need outdoor recreation for compensation.

3. Most professions are monotonous; therefore their dulling effects upon the mind should be overcome by recreation that provides mental exercise.

Better Regulation of Work Needed

Assuming the correctness of these premises one easily recognizes that, because of leaving work and

idleness distributed at random, the present system of unrestricted labor and unrestricted unemployment is the incorrect answer to this problem. The only logical measure is to regulate work so much that every man or woman from 17 or 18 up to 45 or 50 yr. old can be provided with work. A 5-day week and a 6-hr. day would suffice for the needs of most countries. The rest of the time can be devoted to healthful recreation. This regulation should be revised periodically according to variations caused by seasons and business cycles. The sick and the old should be protected from destitution by compulsory invalid insurance and old age pensions, or else given a chance to accumulate enough capital to meet such contingencies.

I am convinced that in the adoption of such a scheme lies the opportunity to eliminate the disadvantages of mechanization, and to utilize its benefits in such a fashion as to enable us to live agreeable, healthy lives in greater conformance with the rules of nature and the teachings of modern medicine. It is to be hoped that the present depression will serve as an impetus to give it a trial.

Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

Analysis of Equivalent Circuits

Analysis of various circuit problems may be facilitated by the substitution of equivalent circuits which reduce the complexity and permit the replacing of magnetic coupling with simple impedance links so that the calculating board may be used for solution. In this article, general methods of solving the transformer, network, and zero phase sequence problems are presented along with useful diagrams and equations for particular cases.

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EQUIVALENT circuits are used in the analysis of certain circuit problems. The method consists of replacing the magnetic or electrical system to be analyzed with a simplified equivalent linkage of simple impedance links which satisfies the same terminal conditions. In general, any problem which can be analyzed with an equivalent circuit can be analyzed without it. However, the equivalent circuit may be useful for any or all of the following reasons:

1. Since the equivalent circuit represents only terminal conditions, it is frequently simpler than the actual machine or circuit.
2. The use of the equivalent circuit speeds up and systematizes calculation, in some cases reducing the amount of calculation.
3. The equivalent circuit aids in visualizing the problem.
4. Since the equivalent circuit is made up of simple impedance links, it may be set up readily on the calculating board, thereby lending itself to the solution of complicated networks.

Based upon "Equivalent Circuits—I" (No. 32-21) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

Three closely related types of problems present themselves; namely, the transformer problem, the network problem, and the zero phase sequence system problem. This latter arises primarily through the difficulty experienced in adequately representing on the calculating board, groups of parallel transmission lines in which zero phase sequence currents are flowing. To represent such a group it is desirable to replace it with an equivalent circuit in which mutual impedances between the lines are simulated by simple impedance links. The method of determining such an equivalent circuit is presented in this article following a discussion of the first two types of problems.

The two generalized equivalents discussed under the first two problems are quite broad and should find many applications other than those cited. Only linear circuits and networks are dealt with, however, and in general the circuits developed are equivalent only at a single frequency, although certain ones such as in Figs. 7, 8, and 10 to 13, are equivalent at all frequencies.

The Transformer Problem

In practise, the multi-circuit problem, that is, the problem of a number of circuits each having a self-impedance and a mutual impedance with every other circuit, frequently presents itself. It is usually desired to determine the current in each branch, having given the voltage impressed across each circuit. If the calculating board is to be used in the solution of such problems, the system of coupled circuits must be replaced by an equivalent linkage, since magnetic coupling of adequate flexibility usually cannot be simulated on the calculating board.

Equivalent circuits for the relatively simple case of the two-winding transformer are shown in Fig. 1. In the conventional equivalent circuit of Fig. 1(b) all impedances must be expressed on a common voltage

base since the same current flows in each. If α is the ratio of primary to secondary turns, then the values of Z_1 and Z_2 referred to the primary are, in terms of the magnetizing and mutual impedances (called the characteristic A coefficients):

$$Z_1 = A_{11} - A_{12}a \tag{1}$$

$$Z_2 = A_{22}a^2 - A_{12}a \tag{2}$$

Similar circuits have been developed for the three-winding transformer and the double-winding generator, the value of this type of circuit being discussed in "Theory of Three-Circuit Transformers," by A. Boyajian, A.I.E.E. TRANS., v. 43, 1924, p. 508–29. In the same paper the general equations for setting up a similar type of circuit for the n-winding transformer are written. The equivalent circuit of Fig. 1(c) while still not strictly correct, represents more nearly

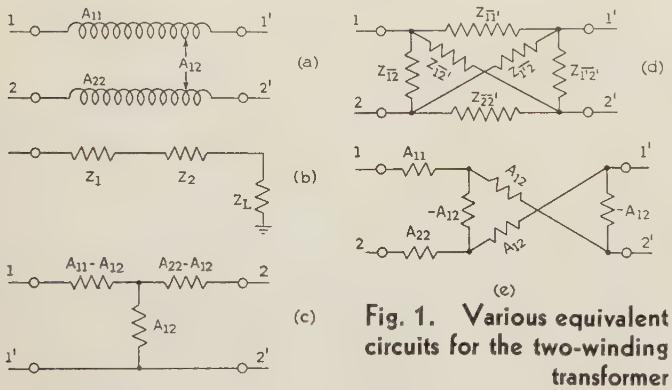


Fig. 1. Various equivalent circuits for the two-winding transformer

(a) The two-winding transformer, in which A_{11} is the primary self-impedance or magnetizing impedance, A_{22} is the secondary impedance, and A_{12} is the mutual impedance between the windings

(b) Conventional equivalent circuits used for calculating regulation, magnetizing current being neglected. This circuit gives no voltage transformation. Z_1 is primary leakage impedance (resistance plus leakage reactance), Z_2 is secondary leakage impedance, and Z_L is load impedance, all expressed on a common voltage base

(c) Equivalent circuit which gives voltage transformation and does not neglect magnetizing current. This circuit must be viewed from one winding only, since it falls down when viewed as a four point network

(d) A rigorous equivalent for the two-winding transformer which cannot be distinguished from the actual transformer under any imposed terminal conditions

(e) An equivalent equally as rigorous as that of the Fig. 1(d), but much simpler

the actual transformer. In this circuit the short-circuit impedance of the primary is

$$Z = \frac{A_{11}A_{22} - A_{12}^2}{A_{22}} \tag{3}$$

A general equivalent circuit for the n-winding transformer having $2n$ points of entry has been derived. This circuit is a mesh composed of $n(2n - 1)$ impedance links, one connecting each point of entry with every other point of entry. The impedance of the link connecting the two points of entry of some winding j, i. e., points j and j', is the driving point impedance from point j; and the link connecting two points of entry of two different windings, say points j and k' of windings j and k, is equal to the transfer impedance between points j and k'. These link impedances may be measured directly or calculated from known transformer constants, the A coefficients.

The general equivalent circuit for the two-winding transformer is shown in Fig. 1(d) and is seen to consist of a six-link mesh, the values of which are

$$Z_{\overline{11'}} = \frac{A_{11}A_{22} - A_{12}^2}{A_{22}} \tag{4}$$

$$Z_{\overline{22'}} = \frac{A_{11}A_{22} - A_{12}^2}{A_{11}} \tag{5}$$

$$Z_{\overline{12}} = \frac{A_{11}A_{22} - A_{12}^2}{A_{12}} \tag{6}$$

$$= Z_{\overline{1'2'}} = -Z_{\overline{12'}} = -Z_{\overline{1'2}}$$

Equations defining the links for the equivalent mesh to represent the n-winding transformer shown in Fig. 2 have been derived and are as follows:

$$Z_{\overline{kk'}} = \frac{1}{B_{kk}} \tag{7}$$

$$Z_{\overline{jk'}} = \frac{1}{B_{jk}} = Z_{\overline{j'k}} = -Z_{\overline{j'k'}} = -Z_{\overline{jk}} \tag{8}$$

where B_{kk} is the driving point admittance from point j, B_{jk} is the transfer admittance between points j and k, and Z_{jk} is the impedance of the link connecting any

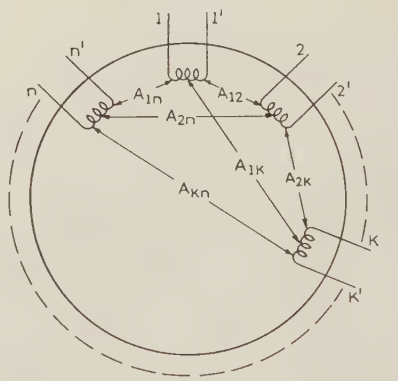


Fig. 2. A system of n electrically isolated but magnetically coupled circuits

Such a system may be replaced by an equivalent mesh of $n(2n - 1)$ links connecting each of the $2n$ points of entry in all possible ways. For example of equivalent mesh when $n = 2$, see Fig. 1(d)

two points of entry j and k. The values of these links for the general case may be calculated or measured directly at the terminals of the transformer. The method of measuring transfer and driving-point impedances is well known. The B coefficients are defined by and may be calculated from the following determinantal relations:

$$B_{jk} = B_{kj} = \frac{Q_{A-jk}}{\Delta_{n-A}}(-1)^{j+k} \tag{9}$$

where

$$\Delta_{n-A} = \begin{vmatrix} A_{11}\, A_{12} \ldots . A_{1n} \\ \cdot \\ \cdot \\ A_{k1}\, A_{k2} \ldots . A_{kn} \\ \cdot \\ \cdot \\ A_{n1}\, A_{n2} \ldots . A_{nn} \end{vmatrix} \tag{10}$$

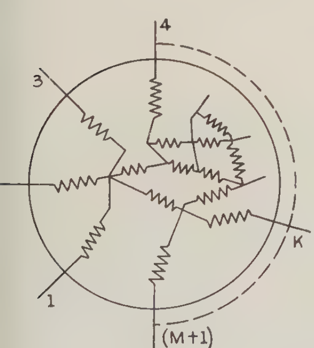
ınd Q_{A-jk} is the cofactor of A_{jk} in Δ_{n-A} (i. e., the ninor of Δ_{n-A} with the j'th column and k'th row leleted) the sign of which is $(-1)^{j+k}$.

The equivalent circuit of Fig. 1(e) is seen to be a ombination mesh and star arrangement, and may be ırrived at by simple reasoning from the mesh of Fig. (d). Since the self-impedance of any winding is ndependent of the other windings, its value need not ppear in any of the mutual links if it be lumped as a adial link at the terminals of the circuit. Thus, etting A_{11} and A_{22} equal to zero in eqs. 4, 5, and 6, nd inserting radial links having impedances equal to $_{11}$ and A_{22} in terminals 1 and 2, respectively, one vill obtain the circuit of Fig. 1(e). This latter cir- uit is much more useful than that of Fig. 1(d) since he mutual links are purely reactive, the resistances ppearing only in the terminal links. This arrange- nent avoids the possibility of negative resistance ppearing in any link. In an entirely similar manner he mesh equivalent of any number of coupled cir- uits may be simplified and rendered more useful by educing to a combination star-mesh arrangement.

'HE NETWORK PROBLEM

In the study of the behavior of a large transmission nd distribution system, the transmission lines and onnected apparatus commonly are represented by an ppropriate single-line diagram, all units of connected quipment being replaced with suitable impedance inks. In most cases no trouble is experienced in napping out the single-line diagram, at least none for he positive and negative phase sequence diagrams, ince standard methods are available for doing this.

In setting up the single-line diagram on the calcu- ating board, for purposes of simplification it may be esirable to replace either the whole system or some ection of it with an equivalent impedance mesh vhich has the same number of points of entry but a reatly reduced number of links. For example, Fig.



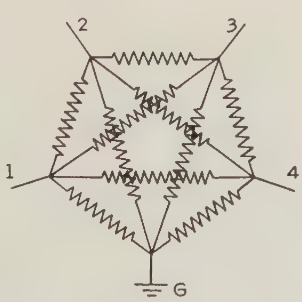


Fig. 3. (Left) A general network, not simplified

Fig. 4. (Right) Equivalent mesh for a network having five points of entry

 shows a complicated network of impedance links aving (m + 1) points of entry. Such a network ıay be replaced with an equivalent mesh having $\frac{(m+1)}{2}$ links, one connecting each point of entry with every other point of entry. The equivalent mesh for a five-point network is shown in Fig. 4 (note that m = 4 and that for purposes of analysis the m + 1 point is considered as a ground point).

The values of the links of the equivalent mesh which is to replace the general network may be determined either by direct calculation from the net-

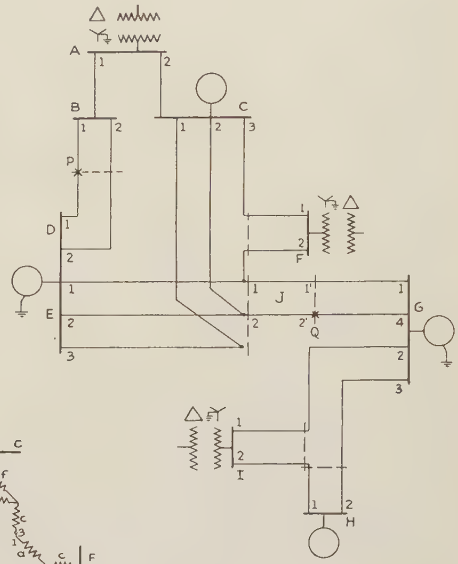


Fig. 5. (Right) Single-line diagram of a transmission system

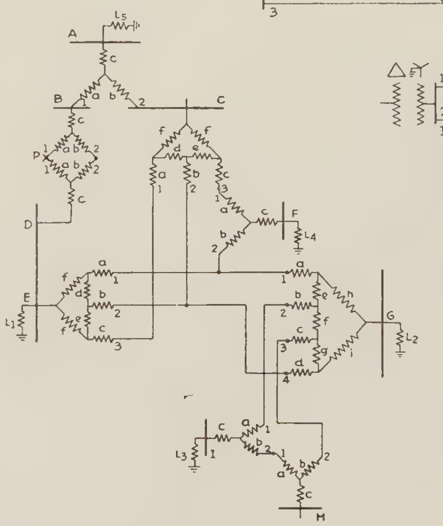


Fig. 6. (Left) Equivalent circuit for the zero phase sequence diagram of the system shown in Fig. 5 for a ground fault at point P

work constants or by measurements made at the terminals of the network. It may be shown that the impedance of the link connecting any two points of entry such as j and k is equal to the transfer impedance between the points j and k, i. e.,

$$Z_{\overline{jk}} = Z_{jk} \tag{11}$$

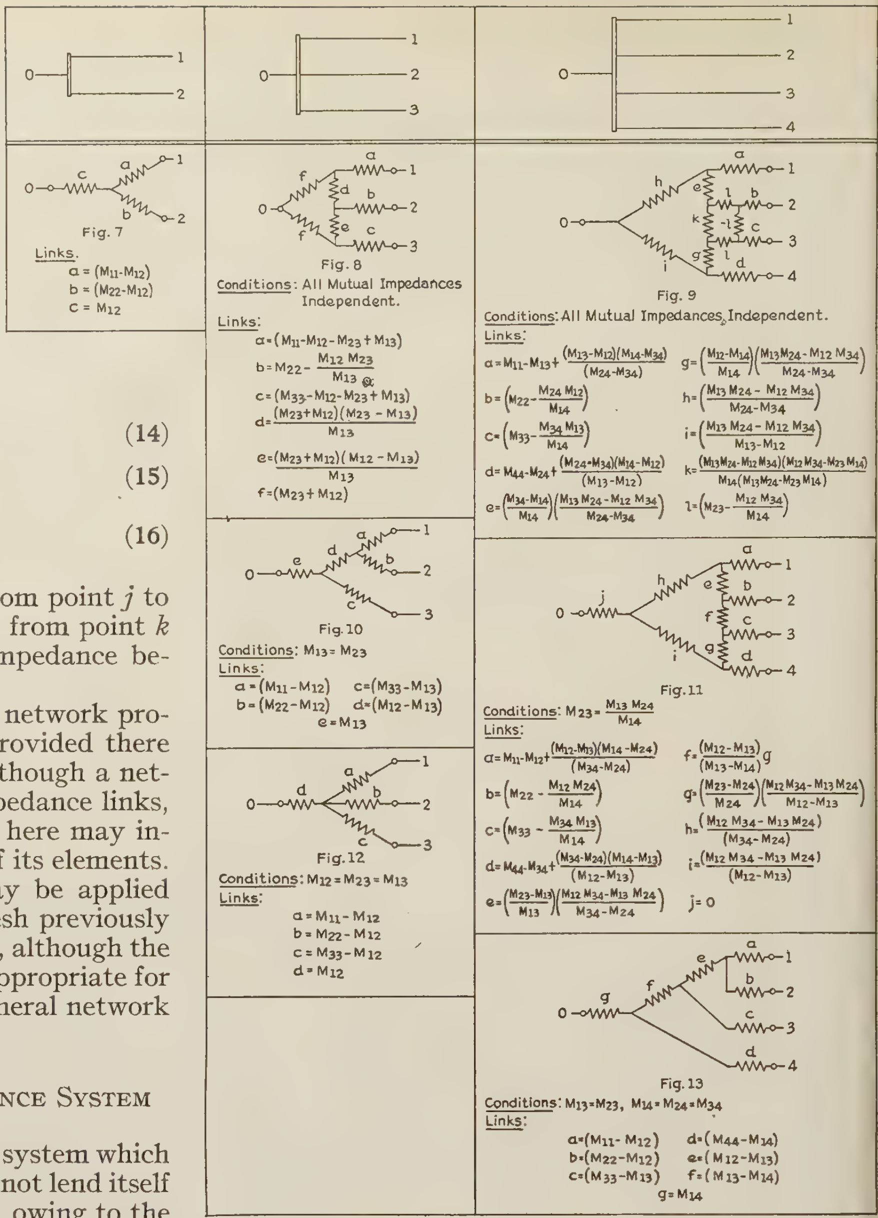
The impedances of the links of the equivalent mesh may be calculated by determinants in terms of the through impedances of the network (by through impedance between any two points such as j and k is meant the impedance between these points with all other points open).

It may be shown that

$$Z_{\overline{jk}} = \frac{\Delta_{m-c}}{Q_{c-jk}} \tag{12}$$

where

$$\Delta_{m-c} = \begin{vmatrix} C_{11}C_{12} \ldots . C_{1m} \\ \cdot \\ C_{k1}C_{k2} \ldots . C_{km} \\ \cdot \\ C_{m1}C_{m2} \ldots C_{mm} \end{vmatrix} \tag{13}$$



Figs. 7–13. From these diagrams, equivalent circuits may be obtained to represent various groups of parallel transmission lines such as shown in Fig. 5 when the zero phase sequence diagram is to be set up on the calculating board

and Q_{c-jk} is the cofactor of C_{jk} in Δ_{m-c}. The characteristic coefficients of the above determinants in terms of the through impedances of the network are:

$$Z_{jj} = Z_{j-0} \tag{14}$$

$$C_{kk} = Z_{k-0} \tag{15}$$

$$C_{jk} = \frac{Z_{j-0} + Z_{k-0} - Z_{j-k}}{2} \tag{16}$$

where Z_{j-0} is the through impedance from point j to ground, Z_{k-0} is the through impedance from point k to ground, and Z_{j-k} is the through impedance between points j and k.

These methods apply to any general network provided the impedances are linear and provided there are no internal voltages. Note that although a network usually is composed of simple impedance links, the general network as it is considered here may involve magnetic coupling between any of its elements. In fact the general network mesh may be applied directly in obtaining the equivalent mesh previously discussed for the n-winding transformer, although the latter mesh is much simpler and more appropriate for the transformer problem than is the general network mesh.

Diagram of the Zero Phase Sequence System

The zero phase sequence diagram of a system which involves parallel transmission lines does not lend itself so readily to a calculating board set up, owing to the fact that when zero phase sequence currents are flowing in the parallel lines, the mutual magnetic coupling between them cannot be neglected; neither can it be represented adequately by the usual calculating board equipment.

A typical example of a system involving groups of parallel lines is shown in Fig. 5. The analytical determination of the currents in every branch of this system due to a ground fault practically is impossible, but if each group of parallel lines is replaced with an equivalent linkage, the calculating board may be applied to obtain an exact solution.

A group of circuits representing two, three, and four parallel lines under various conditions is shown in Figs. 7 to 13, inclusive. Since more than four parallel lines seldom exist for any great distance, equivalents for groups of more than four lines have not been derived; however, should a case arise in which more than four parallel lines do occur, appropriate circuits readily may be developed.

In regard to this special group of equivalents for parallel lines it should be noted that:

1. The values of impedance links are short usable expressions in terms of the self-impedances and mutual impedances of the lines, which are constants usually known.
2. Negative impedance links usually may be avoided in the application of these circuits (the circuits of Fig. 9 being excepted) thereby permitting the use of the d-c. calculating board where resistance may be neglected.
3. The self-impedance of each line appears only in the radial link at the terminal, the mutual links being purely reactive. This arrangement insures that negative resistance will always be avoided.

To illustrate the utility of these special circuits, the system of Fig. 5 is shown in an equivalent form in Fig. 6. Here each group of parallel lines is replaced with an appropriate equivalent. Note that the links of these equivalent circuits are all expressed in terms of the self-impedances and mutual impedances of the lines, M_{jj} being the self-impedance of line j and M_{jk} being the mutual impedance between lines j and k. These coefficients are usually known, and if not, they may be readily measured or calculated. The set-up of Fig. 6 may be placed upon the calculating board and used for determining the magnitude and distribution of ground-fault currents for various fault locations, as, for example, at some point P, or on any bus.

Concentration of Heating Currents

The proximity effect, usually considered as undesirable and wasteful, may be used to concentrate heating currents in predetermined strips of conducting bodies. Both the current density and shape of the strip may be so controlled as to make this method valuable in a number of heating processes.

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ELECTRIC heating currents frequently are used in industrial operations such as welding, forming, and hardening. Where it is desired that the heating be confined to predetermined strips of the conducting bodies, the "proximity" effect may be utilized to control the path of the heating current.

The "proximity" effect, as it is called, is the redistribution of the current densities over the cross-section of conductors which occurs when 2 conductors at first remote from each other are brought into close proximity. Currents flowing in opposite directions in two such conductors cause the current density in the closely adjacent filaments of the conductors to be higher than in the more remotely separated filaments. The less the separation of the conductors and the higher the frequency, the greater will be the variation of the current density. This effect may be magnified to serve a very useful purpose in many industrial heating operations.

Bibliographies of the literature dealing with the distribution of current densities over the cross-section of conductors will be found at the end of the following papers: "Experimental Researches on Skin Effect in Conductors," A. E. Kennelly, F. A. Laws, P. H. Pierce, A.I.E.E. TRANS., v. 34, 1915, p. 1953–2018; and "Bessel Functions for Alternating Current Problems," H. B. Dwight, A.I.E.E. TRANS., v. 48, 1929, p. 820. The second bibliography contains references to papers appearing since the preparation of the first.

The confining of the heating currents to predetermined strips is accomplished by using currents of a frequency in the range known as the audio range, and by the electrical connections and space arrangements illustrated in Figs. 1 to 6. An examination of these arrangements will show that they may be grouped under the following classifications:

1. Current conductively conveyed to the body to be heated.
   a. The shapes and the connections of the heated bodies alone determine the strips in which the current concentrates. See Figs. 1, 2, and 3.
   b. An auxiliary water-cooled conductor is used to determine the strips of concentration. See Figs. 4 and 5.

2. The current is induced in the strip to be heated. A tubular water-cooled inducing coil lies in close proximity to the strip and there is no conductive connection with the body to be heated. See Fig. 6.

In each diagram, the transformer symbol represents the source of audio frequency current. The arrows represent the directions of the currents at a given instant of time. For the sake of clearness it has been necessary to draw the parts with considerable distance between the adjacent edges; but in the actual equipment, this gap is of the order of a few millimeters or centimeters, depending upon the thickness of the edges. The heating currents may be confined to layers ranging in depth from a few millimeters to several centimeters.

The first sight of the red-hot strip of steel conforming to the sinuosities of the water-cooled copper tube mounted above the steel plate illustrated in Fig. 5 is found to be somewhat startling even to engineers who have witnessed the heating effects obtained with the arrangements shown in Figs. 1, 2, and 3.

In all of the arrangements illustrated in these figures, the control over the pattern according to which the current densities are to decrease from the center line to the edges of the selected strip and from the surface of the strip to the interior of the body is had by the joint adaptation of 3 things; namely, the frequency of alternation of the heating currents,

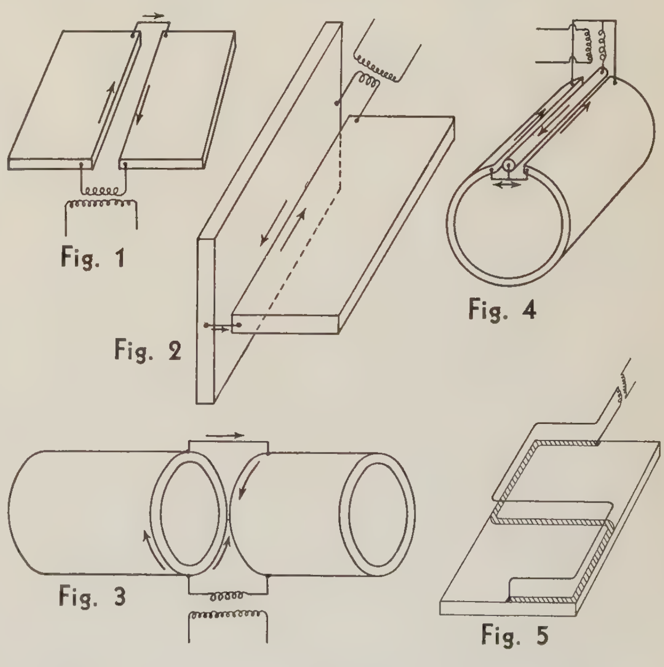

Fig. 1. Connections for heating edges of plates
Fig. 2. Connections for heating an edge and a strip
Fig. 3. Connections for heating ends of pipes
Figs. 4 and 5. Connections for an auxiliary conductor which determines the path of the heating current

Based upon "The Proximity Effect, Its Application to the Concentration of Heating Currents in Predetermined Strips" (No. 32-54) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

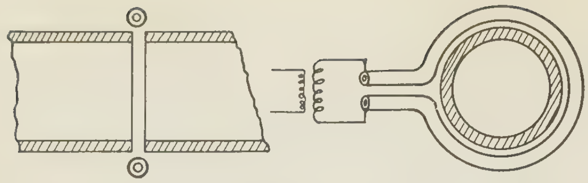

Fig. 6. Strip heating by an inducing coil

Table I—Values of the Penetration Unit

Material Temp. °C.		Relative Resistivity	Relative Permeability	Frequency	Conductivity mho-cm.	P. unit cm.
Copper	20	1	1	960	580,000	0.214
Steel	20	11	100	960	52,700	0.070
Steel	800	94	1	960	6,240	2.06
Steel	1,300	100	1	960	5,800	2.14
Earth		5.8×10^9	1	60	10^{-4}	65,000

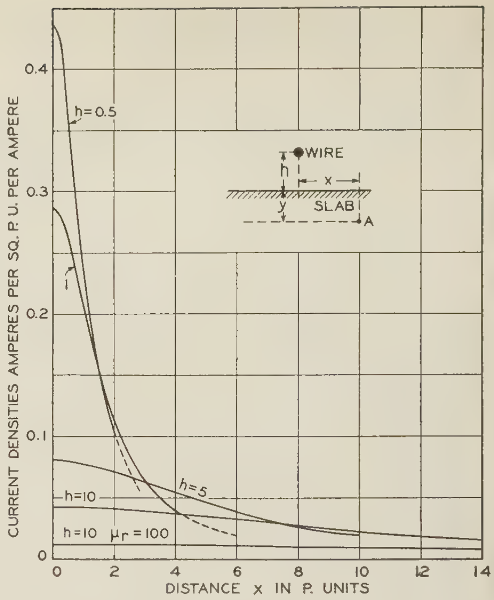

Fig. 7. Current densities at the surface of a slab for different mounting heights

Current densities are expressed in amperes per sq. penetration unit per ampere of heating current flowing in the auxiliary conductor. The distances x and h are expressed in penetration units

the distance from the surface of the strip to the second conductor, and the width and cross-sectional shape of this second conductor. A high-frequency, a short distance between the surface of the strip to be heated and the second conductor, and a narrow second conductor lead to the concentration of the heating current in a narrow strip.

In dealing with the distribution of alternating currents over the cross-section of conducting bodies, it is very helpful to express all linear dimensions, not in centimeters but in terms of a unit of length appropriate to this problem. This unit of length may be called the "penetration unit" for the material at the frequency in question. The advantage of using this unit is that it makes possible the representation, by a few curves, of the distribution of the current for a wide range of conducting materials, spacings, and frequencies.

The length of the penetration unit is,

$$1\ P \text{ unit (penetration unit) (in cm.)} = \frac{1}{\sqrt{\pi f \mu \gamma}} \qquad (1)$$

where

f represents the frequency
γ represents the conductivity of the conductor in mho-cm.
μ represents the permeability of the conductor in weber ampere-turn cm. units. ($\mu = 4\pi 10^{-9}$ for non-magnetic materials.)

The values of the penetration unit for different materials and frequencies are as shown in Table I.

In order that a physical significance may attach to the penetration unit as defined in eq. 1, the following statements may be noted. The effective resistance to an alternating current of frequency f of a conductor of circular cross-section, the radius of which is 5 or more times the penetration unit of the material at the frequency f, is approximately equal to the ordinary ohmic resistance of a surface layer of the conductor having a depth equal to the penetration unit. Again, at a depth of 1 penetration unit below the surface of such a large conductor, the current density is approximately 36.8 per cent of the density at the surface, and it lags by 1 radian behind the current density at the surface.

To illustrate the extent to which heating currents can be caused to concentrate in narrow strips by enhancing the proximity effect, the current densities have been worked out and plotted for the arrangement illustrated in Fig. 5, except that the auxiliary conductor has no sinuosities but is in the form of a long straight wire mounted over a wide conducting slab of a thickness 5 or more times the penetration unit of the material at the operating frequency. The radius of the auxiliary conductor has been assumed to be very small in comparison with its mounting height, h, say 5 per cent or less.

The current density C at any point A in the slab may be computed from the following Fourier integral.

$$C = \frac{j\,2\,I}{\pi}\int_0^\infty \frac{1}{\sqrt{b^2+2j}+b\mu_r}\cos xb \exp\left(-hb - y\sqrt{b^2+2j}\right)db \qquad (2)$$

where

C represents the current density at A in amperes per sq. Pen. unit
b represents the variable of the integrand. It disappears from the integral upon substituting the two limits 0 and ∞
I represents the value of the heating current in amperes
h represents the height of the auxiliary conductor above the surface
y represents the depth of the point A below the surface
x represents the x coordinate of the point A, as shown in Fig. 7
μ_r represents the relative permeability of the conducting slab
j represents $\sqrt{-1}$
exp $(-hb)$ represents the exponential series in $(-hb)$. (The values of x, y, and h are to be expressed in P units.)

Eq. 2 is valid for materials and frequencies in which the conduction current density is 100 or more times as great as the displacement (charging) current density. For copper at a frequency of 1,000 cycles per sec., the conduction current density is 10^{15} times the displacement current density.

If the slab is of non-magnetic material, or of ferromagnetic material at temperatures above the point at which the material becomes non-magnetic, μ_r has the value unity, and eq. 2 reduces to the following

orm which is equivalent to that given by J. R. Carson in "Wave Propagation in Overhead Wires With Ground Return," *Bell System Tech. Jl.*, Oct. 1926, p. 539–54.

$$C = \frac{I}{\pi} \int_0^\infty [\sqrt{b^2 + 2j} - b] \cos xb \exp (- hb - y \sqrt{b^2 + 2j})\, db \qquad (3)$$

For mounting heights for the auxiliary conductor in which h is greater than 20 penetration units, eq. 3 for non-magnetic materials evaluates to the simple form

$$C = \frac{1 + j}{\pi} \frac{h}{h^2 + x^2} (\exp - y) (\cos y - j \sin y)\, I \qquad (4)$$

An examination of Table I will show that the value of the penetration unit for steel at a frequency of 960 cycles per sec. lies between 0.07 cm. for steel with an assumed relative permeability of 100 and 2.14 cm. for steel at a temperature of 1,300 deg. cent. For an auxiliary conductor mounted at a height of 1 cm. above the conducting slab, the important range of mounting heights for this steel would lie between $h = 0.5$ and $h = 20$ penetration units.

In Fig. 7 are contained curves, each worked out for a different mounting height of the auxiliary conductor, which show the manner in which the current density at the surface of the slab falls off on each side of the center line of the heated strip. All the curves have been plotted for material in the non-magnetic state save the curve marked $\mu_r = 100$, in which the relative permeability has been taken to be 100. The effect of the permeability of the steel in confining the current to a thinner surface layer of the steel and thereby causing a wider spread of the current is to be noted.

A mounting height of one penetration unit means that the height of the auxiliary conductor above the slab would be about 2 cm. for a steel slab with a strip at its welding temperature and a 960 cycle heating current. For this important case, Figs. 8 and 9 show the distribution of current densities at the surface and at points in planes located at depths of 1 and 2 penetration units below the surface. These figures also show the phase of the current density at these points, relative to the phase of the total heating current. The current density along the center line of the strip is seen to be 60 deg. in advance of the total current. At points in planes 1 and 2 penetration units beneath the surface, the current density lags substantially 1 and 2 radians behind the current density at corresponding points on the surface, and has decreased to roughly $(1/\epsilon)$th and $(1/\epsilon)^2$ of its value at the surface. In the surface at a distance of 2 penetration units from the center line of the strip, the current density is seen to be 40 per cent of the value on the center line, and thus the power expenditure per unit volume is only 16 per cent as great as along the center line.

The relative effect of close proximity of the auxiliary conductor and of a high frequency of alternation in contributing toward the concentration of the heating currents in narrow strips is brought out more clearly by plotting the current densities at the surface against the ratio of the distance x of the filament to the mounting height h of the auxiliary conductor, as in Fig. 10.

Economic and Practical Features

A number of important questions of an economic and practical nature remain to be solved before the

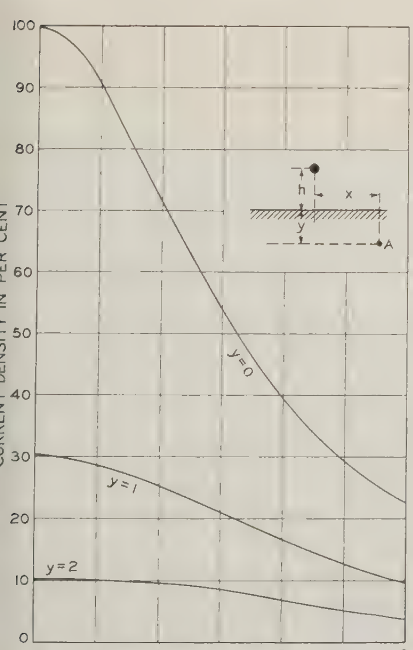

Fig. 8. Current densities for a mounting height of one penetration unit

The current densities are given in per cent of the current density directly below the wire. x, y, and h are in penetration units

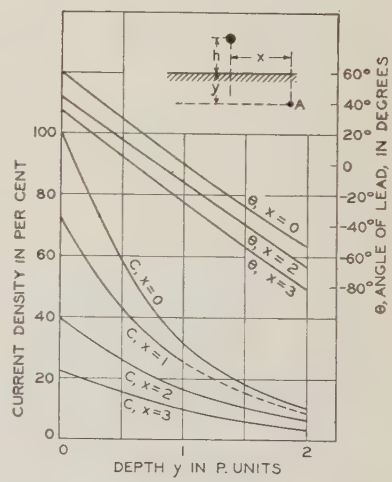

Fig. 9. Current densities and phase angles for a mounting height of one penetration unit

The current densities are given in per cent of the current density directly below the wire. x, y, and h are in penetration units. The phase angles are the angles by which the current density leads the heating current

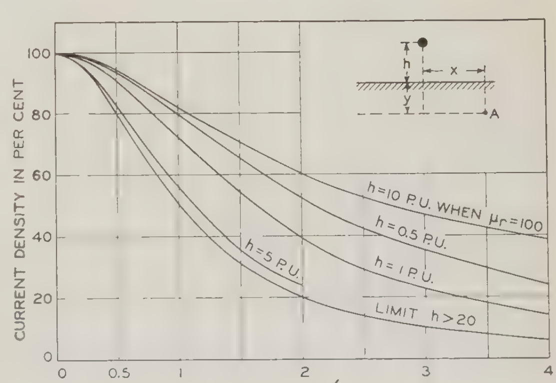

Fig. 10. (Right) Current densities at the surface of a slab

For each height of wire, the current densities are expressed in per cent of the current density existing immediately under the wire at that height. The distance h is expressed in penetration units

practise of selective heating, by means of the proximity effect, can be established as a shop process. The experiments upon which this article is based have been limited to the experience to be had with a condenser mercury-spark-gap source of high frequency currents having a rating of 35 kw.

The most economical range of frequencies for use in the process remains to be determined. Many factors which vary from operation to operation, such as the kind and size of material to be heated, the nature of the desired temperature pattern, and the relative cost of generating energy at the different frequencies will serve to determine the range of frequencies which will be the most economical. Present experience would indicate that the economic frequencies may be expected to center upon 960 cycles per sec.

Unquestionably the control of the distribution of heating currents which is made possible by the application of the proximity effect opens up a new range of industrial heating effects. It is possible to raise the temperature of a predetermined strip a few millimeters deep in a conducting plate to reach a welding temperature, while portions of the plate a few centimeters away may be substantially at room temperature. On the other hand, more gradual changes in temperature also may be secured if desired. A hitherto unattainable nicety of control of the distribution of temperatures in bodies is made available by the application of the proximity effect.

Conductor Vibration on Transmission Lines—II

Field tests substantiate the results of theoretical and laboratory investigations of conductor vibration on electric power transmission lines treated in an article appearing in the July issue of ELECTRICAL ENGINEERING. Among other important findings it is shown that adequate practical protection against damage from conductor vibration can be provided by the proper use of armor rods or dampers.

By
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FIELD OBSERVATIONS of conductor vibration on operating power lines in various parts of the country have been coordinated with laboratory research. Early in 1930 it was decided to establish a field laboratory equipped for accurate study; accordingly a station was established near Royse City, Texas, about 35 miles east of Dallas. Chief among the considerations which led to the selection of this site were the flat unobstructed topography and the remarkably steady wind conditions. A vacant position on an existing steel tower line was

Fig. 8. Observation structures for field tests, Royse City (Tex.) experiment station

made available for experimental work by the Texas Power and Light Company and additional spans were erected on wood H-frames at nearly a right angle to the existing line. This site has proved to be excellent, for hardly a day has passed without vigorous vibration being recorded on at least 1 of the 2 test lines.

In addition to the field studies at Royse City, observations have been conducted on operating lines as follows:

1. The Public Service Electric and Gas Company of New Jersey 220-kv. Roseland-Bushkill line; 795,000-cir. mil A.C.S.R. conductor and 203,000-cir. mil A.C.S.R. ground wire.

2. The Pennsylvania Power and Light Company 220-kv. Plymouth Meeting-Siegfried line; 184,000-cir. mil ground wire.

3. The Idaho Power Company 132-kv. Caldwell-Ontario line; 4/0-A.C.S.R. conductor.

Engineers of the New England Power Company have observed that under certain conditions a charged conductor tends to vibrate, presumably from the effect of corona. While allied to the general problem of conductor vibration the occurrence of vibration of this sort is probably rare. The Pacific

Essentially full text of the last portion of a paper, "Vibration of Overhead Transmission Lines" (No. 32-90) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

Gas and Electric Company has made field observations of conductor vibration, and also laboratory experiments on vibration dampers. Space limitations, however, prevent including more than reference to the experimental work of these and other companies.

ARRANGEMENT OF TEST EQUIPMENT

At Royse City two test lines are available at an angle of 74 deg. thus insuring one line being favorably exposed for vibration regardless of wind direction; span lengths are 650 and 1,225 ft. on the steel towers, and 416 and 1,226 ft. on the H-frames. The ground wire on the steel towers is $^3/_8$-in. diameter 7-strand steel, while the conductors of the 132-kv. circuit on the towers are 4/0 A.C.S.R. (aluminum cable steel reinforced) equipped with armor rods. Other sizes and special types of conductors have been installed and observed for short periods. Conductor tensions are adjustable at the anchorages. General arrangement of the observation towers, which extend 12 ft. out under the conductors, may be seen in Fig. 8.

A satisfactory instrument for obtaining 24-hour vibration records was made by using an 8-inch diameter wax-coated, clock-driven chart on which the vertical motion of the conductor was recorded by a stylus attached to a pivoted arm. (See Fig. 9.) For small conductors the inertia and friction of the pivoted arm damped the vibration considerably; therefore a very light stylus attached directly to the cable was substituted. This latter arrangement, however, is satisfactory only if longitudinal motion of the conductor is restrained.

A continuous record of wind direction and velocity was obtained by an anemometer which records electrically the passage of each mile of wind on a strip chart, and a weather vane with a cam-actuated pen which records direction simultaneously on the same chart. The velocity for short periods was determined with a stop-watch and buzzer which indicates $^1/_{60}$ of a mile.

The frequency recorder consists of a uniform-speed motor-driven strip chart on which a trace of the vibration is recorded by a pencil connected to the line by a cord and spring. In addition to the foregoing, a thermograph was used to record temperature, and provision was made for observing sag and tension in the conductors.

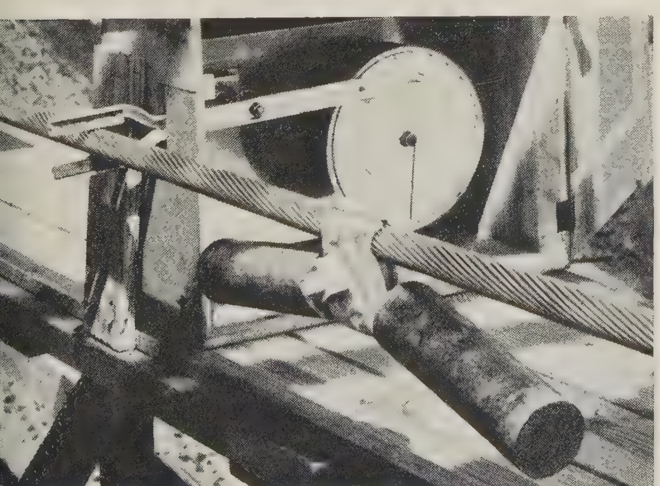

Fig. 9. Conductor vibration recorder

THEORETICAL CHARACTERISTICS OF VIBRATION

In Fig. 10 is given a graphical solution of eq. 1 ("Conductor Vibration on Transmission Lines—I," ELECTRICAL ENGINEERING, July 1932, p. 482–7). This shows the theoretical relations between fre-

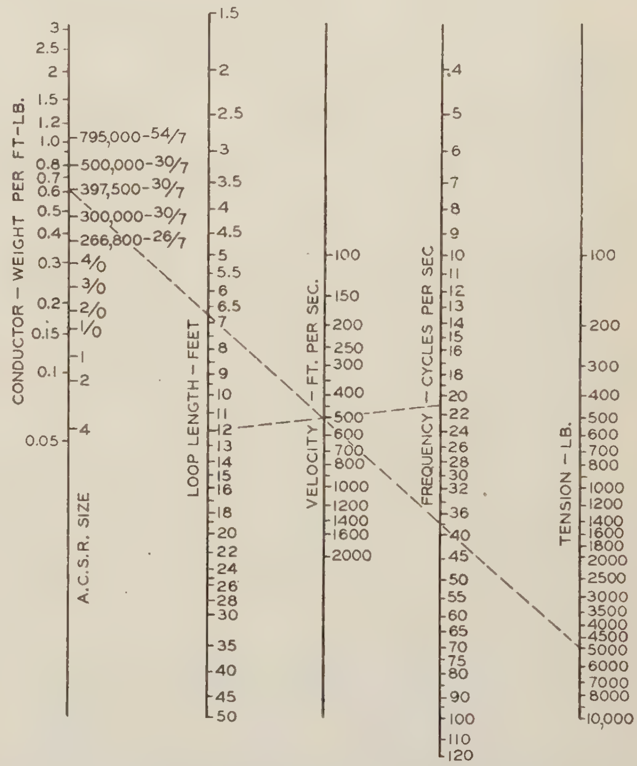

Fig. 10. Relation between weight, tension, loop length, and frequency of a vibrating cable

quency, loop length, tension, and weight of a vibrating cable for common conductor sizes and tensions. A formula expressing theoretical frequency of vibration developed experimentally by Relf and Ower ("The Singing of Circular and Stream Line Wires," Aeronautical Research Committee *Report No. 825*, March 1921) is as follows:

$$f = k \frac{V}{D} \tag{14}$$

where

V = velocity of wind in mi. per hr.
D = outside diameter of the cable in in.
k = a function of (VD/e) where e depends upon the medium, e being 0.000159 for air. For ordinary sizes of conductor k is a constant having a value of 3.26

A graphic solution of eq. 14 is given by Fig. 11. This formula applies to a uniform wind velocity normal to the axis of the wire. Such ideal wind conditions rarely if ever exist over a transmission span, for both velocity and direction have been found to vary widely even in short spans. ("Measurement of Wind Pressures on Overhead Lines," R. H.

Table III—Vibration Data Pertaining to Records Shown in Fig. 12

	Conductor				Wind		Observed Vibration			
Record No.	Cir. Mils or B&S Gage	Diameter in In.	Span Length, Ft.	Tension in Lb.	Velocity Mi. per Hr.	Angle Deg.	Loop Length, Ft.	Amplitude in 32nds In.	Frequency Cycles per Sec.	Calculated Frequency Cycles per Sec.
1	795,000	1.093	1,125	8,216	8	37	24	34	12	11
2	795,000	1.093	1,125	8,216	18	68	$7^1/_2$	18	43	35
3	397,500	0.806	650	3,822	$5^1/_3$	90	15	22	21	16
4	397,500	0.806	650	3,822	$8^3/_4$	90	7	5	34	33
5	4/0	0.563	1,226	2,869	$5^1/_2$	70	$7^1/_2$	14	32	37
6	4/0	0.563	1,226	2,869	10	70	6	4	51	47
7	No. 2	0.316	650	676	5	60	$3^5/_6$	2	60	61
8	No. 2	0.316	650	676	8	60	$2^2/_3$	2	75	85

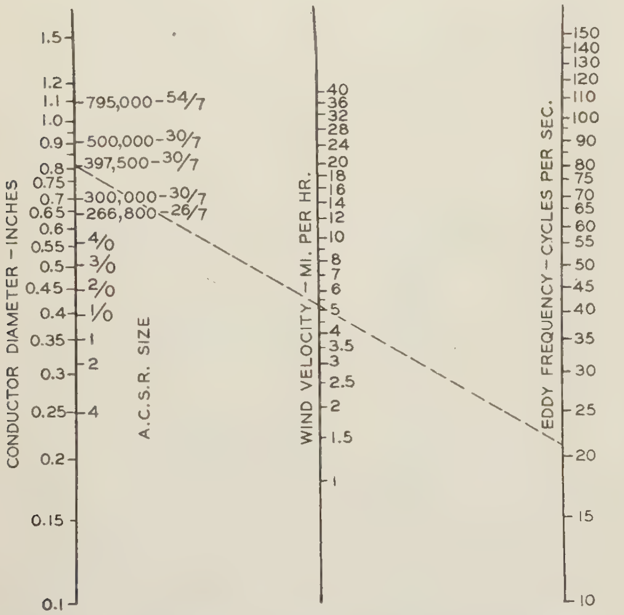

Fig. 11. Graphical solution of Relf and Ower formula for wind eddy frequency of circular cables

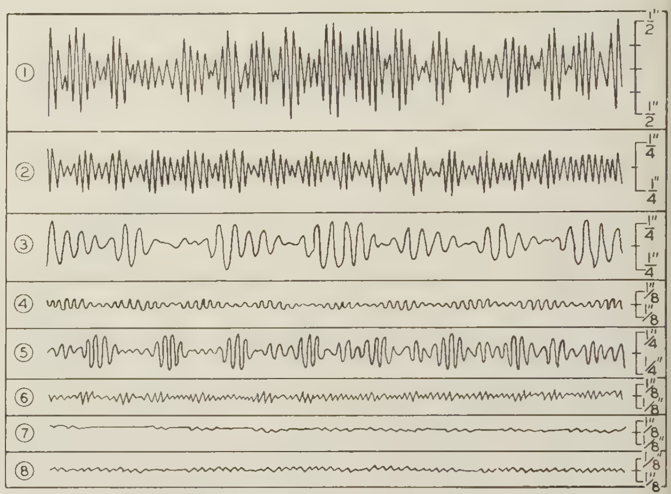

Fig. 12. Vibration records for four sizes of A.C.S.R.; see Table III

Sherlock, N.E.L.A. *Bulletin*, Jan. 1931, p. 29.) ("Characteristics of Wind Gusts," R. H. Sherlock and M. B. Stout, N.E.L.A. *Bulletin*, Jan. 1932, p. 20.) Velocity varies with elevation, and in a long span the height of conductor is not constant; direction shifts rapidly as indicated by any weather vane. The normal component of velocity probably should be used in computing frequency when direction of the wind is oblique. This assumption seems to be in error for small acute angles. A cable has considerable inertia and when once vibrating in any particular mode will not change frequency quickly with slight changes in wind direction or velocity. For these reasons the observed frequency sometimes differs greatly from the theoretical, but with steady wind and obliquity not under 45 deg. the agreement usually is close.

Field Records of Vibration

Numerous records of frequency and amplitude for conductors of various sizes have been obtained. Fig. 12 shows characteristic vibration records for each of four sizes of A.C.S.R. with pertinent data given in Table III. Agreement between observed and calculated frequencies is fairly close. These records all show recurring beats, possibly caused by variations of wind velocity; with span length and frequency known, the time between recurrences of any particular beat determines velocity of wave propagation, tension, and theoretical loop length.

Observation proves the statement that cables of any material will vibrate when conditions are favorable. One of the earliest instances of damage from vibration was recorded over 20 years ago on the Carquinez Straights Crossing of the Pacific Gas and Electric Company. A few years after installation breakage of strands was discovered in the heavy plough-steel conductors. It is interesting to note that the use of parallel reinforcing or stiffening cables extending some distance out from the support, which was developed here, have been used since on many long river crossing spans.

Records of frequency and amplitude of vibration for conductors made of materials other than A.C.S.R. are shown in Fig. 13; data pertaining to these records are given in Table IV.

Influence of Tension

Vibration frequency is a function of wind velocity and diameter of conductor and is independent of tension. From eq. 1 it may be seen that for a given frequency the loop length, however, varies directly as the square root of the tension. Therefore, an increase in tension increases loop length and theo-

etically should render it more difficult for the con-uctor to fall into resonance with the wind eddy requency.

Field records to determine the effect of tension vere obtained at Royse City; 2 No. 2 A.C.S.R. onductors were erected on a 416-ft. span with ensions of 500 and 750 lb., respectively. Simul-aneous 24-hr. records were taken for several weeks, typical record being shown in Fig. 14; as may be een, both conductors vibrated for about the same eriod of time and the amplitude increased slightly vith an increase in tension.

Another tension test was made on a 1,160-ft. span f 795,000 cir. mil A.C.S.R. in New Jersey. The ension was 5,400 lb. in one of the parallel conductors nd 9,000 lb. in the other, a difference of over 50 per ent. Comparative records were obtained for sev-ral weeks during which vibration occurred on a few ccasions, but for short periods only. The results vere comparable to those obtained at Royse City.

From these tests it appears that vibration will ccur at any practical tension when wind conditions re favorable. A reduction of tension decreases the irect stress in the conductor but does not decrease he tendency to vibrate.

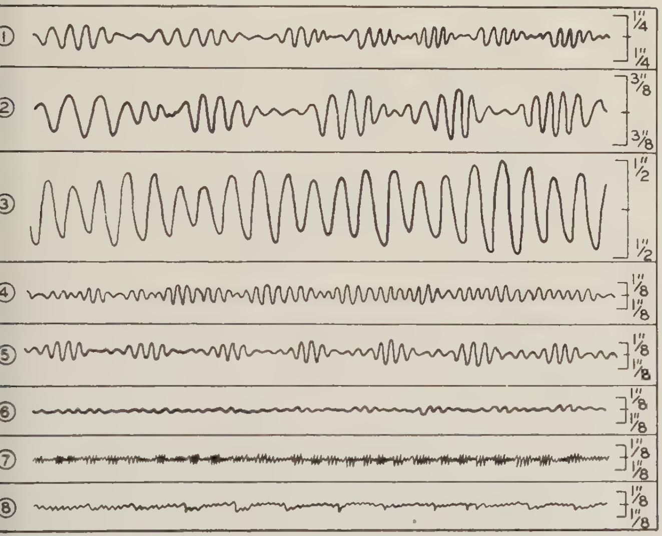

Fig. 13. Vibration records for cables of various materials; see Table IV

Influence of Conductor Shape

It is obvious that the shape of a conductor should influence its vibration, and field tests prove that it actually does. At Royse City the relatively smooth No. 2 and 397,500 cir. mil A.C.S.R. are observed to vibrate more frequently than the 4/0 which has a comparatively rough exterior due to larger strands.

A special test to show influence of shape was made with three No. 2 all aluminum conductors, 1 a single wire, 1 of 3 strands, and 1 of 7 strands. Over a

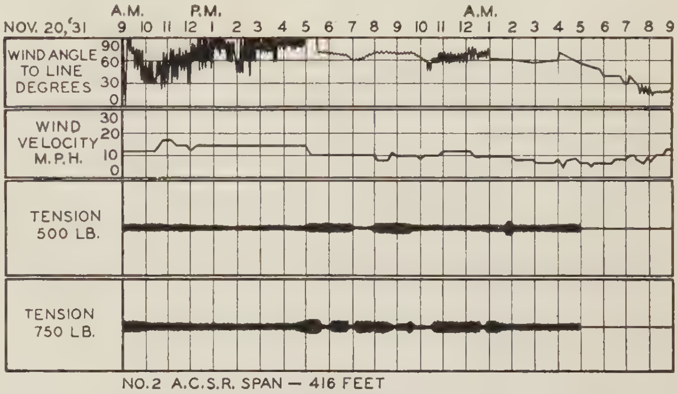

Fig. 14. Vibration records showing effect of tension

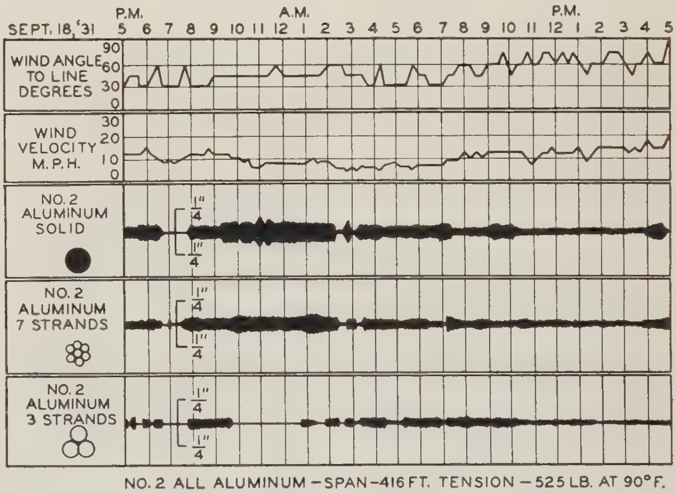

Fig. 15. Vibration records showing effect of conductor stranding

Table IV—Vibration Data Pertaining to Records Shown in Fig. 13

	Conductor				Wind		Observed Vibration			
Record No.	Size and Material	Diameter in In.	Span Length, Ft.	Tension in Lb.	Velocity Mi. per Hr.	Angle Deg.	Loop Length, Ft.	Amplitude in 32nds In.	Frequency Cycles per Sec.	Calculated Frequency Cycles per Sec.
1	650,000 cir. mils copper calson bronze core	1.13	835	9,500	4.5	90	11.5	12	16	14
2	650,000 cir. mils copper calson bronze core	1.13	835	9,500	2	85	17.7	19	10	9
3	400,000 cir. mils 19 str. copper	0.728	1,200	5,100	4	70		32	21	18
4	250,000 cir. mils 19 str. copper	0.575	1,125	5,550	5.75	66	8	9	29	30
5	250,000 cir. mils 19 str. copper	0.575	1,125	5,550	6	66	8	9	25	31
6	4/0 copper	0.528	750	3,200	6.8	80	6.9	6	25	29
7	3/8 in. steel	0.375	650	3,800	8.75	90	3.75	4	88	89
8	3/8 in. steel	0.375	650	3,800	10	75	3	3	99	102

period of several weeks 24-hr. vibration charts were obtained for several tensions. The recorders being set the same distance from the supports, and the tensions being the same, the amplitudes are comparable. Typical charts are shown in Fig. 15; these indicate that the 3-strand cable vibrated least frequently and with the smallest amplitude, the 7-strand was second, and the solid wire vibrated the most. In no case was vibration absent.

Another test was conducted on a special eccentric A.C.S.R. (418,000 cir. mils of aluminum); the outer layer of strands in this cable, being graduated in size, formed an enlargement which wound helically around the conductor axis. This cable was installed on a span of 1,125 ft. parallel to a standard 397,500 cir. mil A.C.S.R. of approximately the same diameter and proportion of steel. A record showing comparative vibration of the 2 cables is shown in Fig. 16.

These experiments show that amplitude can be reduced by variation in shape but that it is doubtful if a practical vibrationless conductor can be obtained in this manner.

Energy Transmitted to Supports

Severe conductor vibration sometimes causes supporting structural members to vibrate noticeably, and fatigue failures at bolt holes in small alloy steel crossarm members have been reported. To measure the variation in vertical load transmitted to the structure a small steel rod of high elastic limit was inserted between the suspension clamp and the insulator string on a 1,125-foot span of 795,000 cir. mil A.C.S.R. An accurate load-deformation curve for this rod had previously been determined with a Huggenberger tensometer. Several readings made under varying conditions of vibration showed that the variation in vertical load was of the order of 100 to 150 lb.

Table V—Vibration Data Pertaining to Records of Fig. 17

	A.C.S.R. Conductors				Recorder
Record No.	Size in Cir. Mils or B & S Gage	Diameter in In.	Span Length, Ft.	Tension in Lb. @ 60° F.	Distance from Support
1	795,000	1.093	1,125	6,755	5 ft. 2 in.
2	795,000	1.093	1,125	6,810	5 ft. 0 in.
3	397,500	0.806	1,125	4,200	4 ft. 5 in.
4	397,500	0.806	1,125	4,085	2 ft. 9 in
5	4/0	0.563	416	2,025	2 ft. 9 in.
6	4/0	0.563	416	2,000	4 ft. 0 in.
7	No. 2	0.316	416	740	3 ft. 1 in.
8	No. 2	0.316	416	720	3 ft. 1 in.

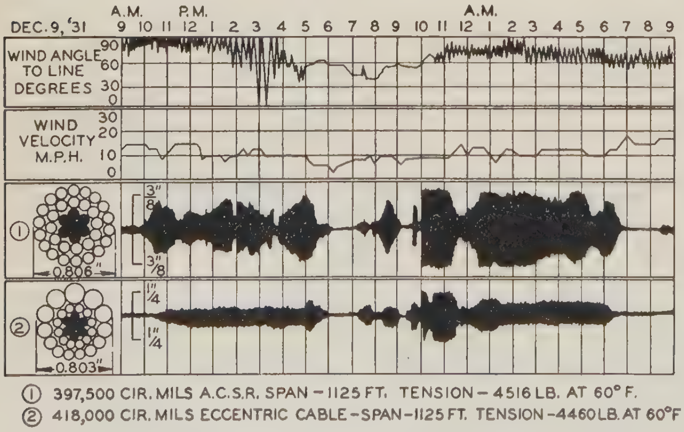

Fig. 16. Vibration records showing effect of eccentric conductor cross-section

Moving Pictures of Vibrating Cable

An ordinary moving picture camera taking 16 exposures per second is too slow to show vibration at a frequency of 25 cycles or more; a high-speed camera, however, taking 128 exposures per second "slows down" the vibration so that the motion of the cable can be followed readily on the screen. One reel was taken of a 795,000-cir. mil A.C.S.R. while the wind velocity was high and the cable vibrating with short loop length, high frequency, and small amplitude. A second reel was taken while the wind velocity was low with correspondingly lower frequency, longer loop length, and greater amplitude. Rocking of the suspension clamp is clearly shown and beat pulsations are evident.

Effect of Dampers

The problem of damping a vibrating conductor differs from many damping problems in that the damper must be effective over a wide range of frequencies. This precludes the use of a tuned dynamic vibration absorber for which the theory was presented by J. Ormondroyd and J. P. DenHartog ("The Dynamic Vibration Absorber," *Trans.*

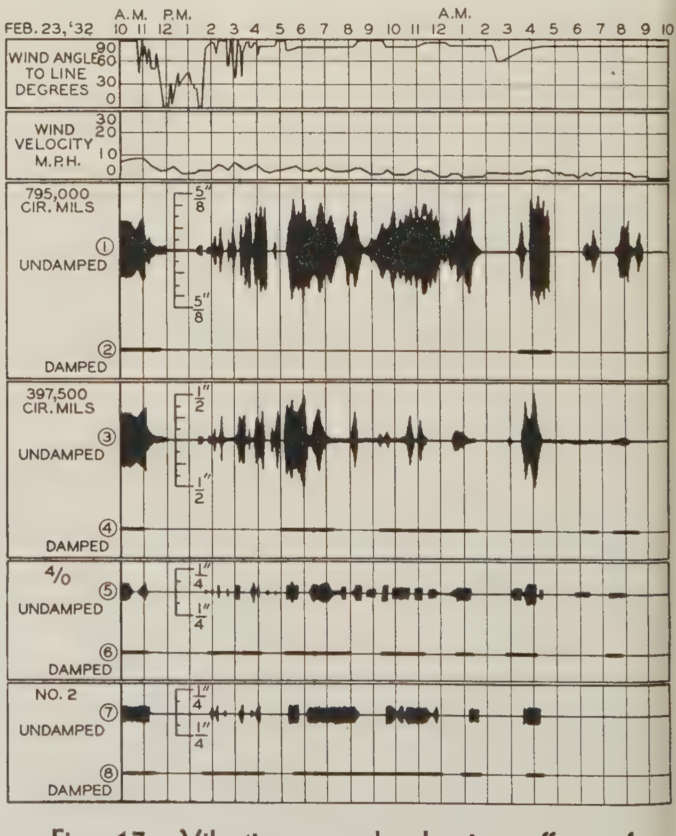

Fig. 17. Vibration records showing effect of dampers on A.C.S.R.; see Table V

Table VI—Vibration Data Pertaining to Records Shown in Fig. 18

	Conductor				Wind		Observed Vibration			
Record No.	Size and Material	Diameter in In.	Span Length, Ft.	Tension in Lb.	Velocity Mi. per Hr.	Angle Deg.	Loop Length, Ft.	Amplitude in 32nds In.	Frequency Cycles per Sec.	Calculated Frequency Cycles per Sec.
1	4/0 A.C.S.R.	0.563	550	2,630	3	75	11.95	6	23	22
2	4/0 A.C.S.R.	0.563	550	2,630	3	75				
3	4/0 A.C.S.R.	0.563	550	2,650	4	75	11.7	8	23	22
4	4/0 A.C.S.R.	0.563	550	2,650	4	75				

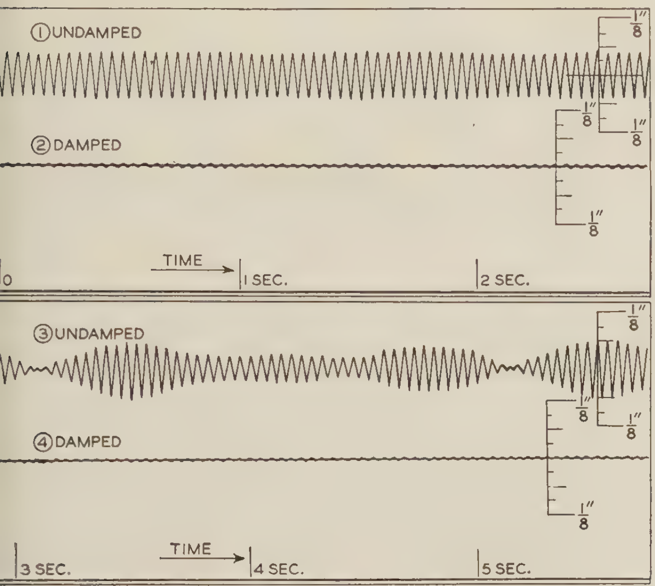

Fig. 18. Oscillographic vibration records showing effect of dampers on 4/0 A.C.S.R., Caldwell-Ontario (Idaho Power Company) 132-kv. line; see Table VI

.S.M.E., 1928). Such an absorber theoretically conımes no energy; hence it seems that it cannot amp vibration where there is a continuing input of nergy as on a transmission line. The dynamic bsorber with damping is effective over a broad band f frequencies and also consumes energy. The neoretical formulas of the Ormondroyd-DenHartog aper for this type of damper are applicable to a ibrating cable in principle only and require extensive nodification and laboratory determination of certain onstants.

It is of interest to note that a simple weight of uitable size at the center of one loop of a vibrating able is somewhat effective as a damper. The added eight alters the natural period of that one loop and, ith the forced vibration which then ensues in that articular loop, the vibration is damped by conimption of energy in the conductor itself in that oop. The practical difficulty is, however, that a ode is soon established at the weight and vibration renewed.

Energy which must be consumed to damp vibraon is undoubtedly extremely small in amount. his is evident from the theoretical formula deeloped by Bate ("The Vibration of Transmission onductors," *Trans.* Inst. Engrs., Australia, 1930, . 277) for the input of energy to a cable from wind ddies. His formula involves several assumptions

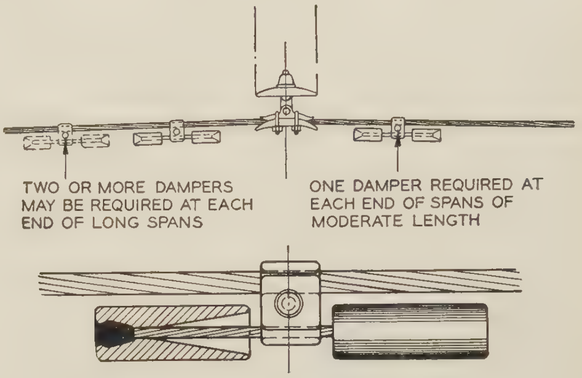

Fig. 19. Stockbridge damper assembly

which have not been proved but the method of derivation is logical and dimensionally it is probably correct. The formula gives the energy input per loop per cycle, G in ft.-lb., as follows:

$$G = 0.000022\ V^2DAL' \tag{15}$$

where

V = velocity of wind in mi. per hr.
D = outside diameter of the cable in in.
A = amplitude of vibration in in.
L' = loop length or distance between node points in ft.

This formula shows that the input of energy is proportional to the amplitude; hence if amplitude can be restrained to a small value the energy input will be small. This agrees with the observed fact that vibration builds up slowly and is damped easily at first.

One reason for establishing the outdoor laboratory was to study the action of dampers. The usual method of observation is by comparison of 24-hr. vibration records from 2 conductors identical in size, span length, and tension, 1 damped and 1 undamped. Many different dampers have been tested at Royse City, and hundreds of comparative records have been obtained.

The most successful damper tested is essentially a mass resiliently attached to the conductor in the loop nearest the support and so designed that energy is consumed by friction or mechanical hysteresis. This damper was developed by G. H. Stockbridge of the Southern California Edison Company. The usual form consists of 2 weights connected by a short piece of stranded steel cable, this assembly being attached to the conductor a short distance out from the insulator. This damper is simple and practical to construct and easy to install, even on hot lines. The weight, size, and length of stranded cable, and location in the span vary for different

diameters of conductor. For spans of moderate length, say under 1,000 ft., 1 damper at each end of the span is required.

Comparative 24-hr. vibration records are shown in Fig. 17 with supplementary data in Table V, for a damped and an undamped span of 4 sizes of A.C.S.R. at Royse City, including wind direction and velocity recorded at one end of the span. It is evident that the dampers suppressed practically all visible vibration; also that the energy input from the wind is directly proportional to the length of the span. In long spans better damping is obtained with 2 dampers at each end, while 3 or more may be required on extremely long spans.

A damper cannot act effectively until the conductor vibration acquires a certain amplitude. This is manifested by a slight quiver which can be felt but barely seen. The 24-hr. charts, however, do not show this clearly. Recently a series of records from a free and a damped span of 4/0 A.C.S.R. was obtained by engineers of the Idaho Power Company using a carbon pile oscillograph; Fig. 18 shows 2 of their oscillograph records. The ripple in the damped cable is scarcely visible even at the enlarged scale.

Many tests on Stockbridge dampers have been made to determine the best dimensions and point of attachment to the conductor. The dampers are not critical either as regards size or spacing—a variation of 25 per cent in any factor will not seriously affect performance. Fig. 19 shows the style of Stockbridge damper used in this investigation. To avoid corona discharge this design embodies cylindrical weights which shield the damper cable, and a clamp having no sharp corners.

Armor Rods

Armor rods are primarily reinforcement but they also are effective as dampers. Numerous comparative records have indicated that they reduce vibration amplitude by 10 to 20 per cent. Armor rods reduce stresses by distributing the bending from vibration, reinforce the cable at the point where the stresses are greatest, and furnish valuable protection against flashover burns.

Conclusions

Principal findings of the field tests described in this article may be summarized as follows:

1. Theoretical formulas (*loc. cit.*) expressing relationship between frequency, loop length, tension, and weight of a vibrating conductor are in good agreement with field observations.

2. The Relf and Ower formula (*loc. cit.*) for the frequency of a vibrating cable is substantially correct.

3. Any suspended cable will vibrate when conditions are favorable.

4. Any feasible reduction in tension will not prevent vibration.

5. Modifications in shape of cable cross section and stranding have some beneficial effect in reducing amplitude, but the results do not support the idea that a vibrationless cable can be evolved.

6. Variation in vertical load transmitted to the insulator is not large.

7. Slow-motion moving pictures of vibrating cable enable the motion to be followed by eye but have been of little assistance.

8. A properly designed damper will prevent vibration of any appreciable amplitude, and since the input of energy from the wind varies directly as the amplitude an effective damper is required to absorb but little energy.

9. The Stockbridge damper gives best results, is simple in design and construction, has no moving parts, and is easy to install.

10. Armor rods are primarily reinforcement although they reduce the amplitude of vibration by 10 to 20 per cent.

11. Adequate practical protection against damage from vibration of conductors is afforded by proper use of armor rods or dampers.

Engineering Subjects in the College Program

For each of a large number of technical institutions, the various electrical and related subjects in the 4-year college program of electrical engineering have been subjected to an analysis. The results of this study are presented herewith, with suggestions for improvement in existing curricula.

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IN THE FIELD of education for electrical engineering both the teacher and the practising engineer are vitally concerned; the teacher, because it is his life work, the practitioner because the young graduates are presumably trained to meet the specifications of his profession, to join its ranks, and to work beside him in the years to come. Obviously the working relations of man to man and the characteristics of the profession will be determined more or less by the nature of the training given the young men who come into it at the rate of approximately 3,000 a year. In this sphere 2 great national organizations, the Society for the Promotion of Engineering Education and the American Institute of Electrical Engineers, have mutual interests and interlocking membership. It would seem well to set aside for the special consideration of the S.P.E.E., the methods of selection, the study of teaching methods, the operating details, and organization of curricula; but certainly then, it is the special function of the A.I.E.E. to advise as to the economic and professional content and interrelations of programs.

Full text of "Engineering Subjects, Electrical and Cognate, in the Four-Year College Program of Electrical Engineering" (No. 32-74) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

As a matter of background, the study of engineer-
ıg education by the S.P.E.E., 1923–1929, brought ut a synthesis of opinion from teachers and engineers s to what engineering curricula should be. This, resented in "Report of the Investigation of Engi-eering Education," v. 1, p. 413, is as follows:

Moderate diversity but tending away from specialization.

Dominance of the scientific and broadly technical content and nphasis.

Inclusion of a well-identified core of required subject matter.

Inclusion, at all stages, of subjects of purely cultural value.

Due emphasis (though not predominant) on the economic aspects engineering and on their bearing on administration and manage-ent.

Coherence of arrangement and coordination of related subjects.

Thoroughness rather than completeness of detail.

It will be remembered with regard to "specializa-ion" that instead of the general sense of the word as pplied to the differentiation of instruction in ac-ordance with the major divisions of engineering—ivil, electrical, mechanical, etc., the S.P.E.E. used he term in the above discussion in a narrower sense s applied to a further degree of differentiation of urricula within the major fields themselves, such, for xample, as the provision of distinct curricula in anitary engineering, structural engineering, and the ke, within the major field of civil engineering. 'here was common agreement between the teachers nd engineers that the primary purpose of instruction ı specialized engineering subjects should be to teach

Table I—Semester Hours Average Requirements for Graduation in Electrical Engineering

S.P.E.E. Report, 1923-1929		S.P.E.E. Report, 1930	
Subject Group	Units	Subjects	Units
		Technological Subjects	
ectrical Engineering	34.4	Major Branch	39.0
ther Engineering	42.1	Other Technical Subjects	23.5
ıgineering Electives	6.8	Electives	10.4
on-Engineering Electives	1.8	Shop	4.6
iscellaneous	0.1	Drawing	7.2
ıys. and Mil. Training	6.6	Phys. and Mil. Education	4.6
oreign Language	2.1	Modern Foreign Language	1.2
ocial Science	4.4	Economics	4.7
ıysical Science	20.6	Physical Science	20.7
ıglish	8.9	English	9.0
athematics	18.9	Mathematics	18.5
otal Non-Engineering	63.6		
otal Engineering	83.3		
otal Prescribed	137.6	Total Prescribed	133.0
otal Elective	9.3	Total Elective	10.4
·and Total	146.9	Grand Total	143 4
umber of Institutions	55	Number of Institutions	51

ındamental principles and methods rather than to ·ain for particular kinds of work. The engineers nphasized the opinion that specialization is out of lace in undergraduate curricula and that thorough ·ounding in fundamentals is of paramount impor-ınce. Yet many of the teachers believed that in eaching specialized engineering subjects there is no ssential conflict between preparation for particular elds of work and training in fundamental principles ıd methods, although the latter should always be ıe primary purpose. It has been a standard educa-tional policy that principles are best taught in connection with their applications, and that the technical subjects proper should serve as media for teaching principles and the characteristic engineering methods of thought and analysis, instead of attempting preparation for specific types of practise.

The engineers were strongly in favor of extended training in economics and for a greater emphasis upon the economic phases in the engineering subjects proper. A large majority of the teachers, engineers, and graduates who were questioned indicated the belief that foreign languages as taught at that time were not of sufficient value to warrant their inclusion as requirements in the engineering curriculum. Both teachers and engineers were in agreement that shop work should not be required of all students, but only of those enrolled in curricula most closely related to the manufacturing industries. As a result of these definite criticisms and recommendations, chiefly with regard to the preparatory and secondary courses in the curricula, many of the colleges have changed their requirements to meet the recommendations. The progress in this respect may be estimated by comparing the 2 columns in Table I. Unfortunately, the 2 tabulations were not made in exactly the same subdivisions, but "Shop and Drawing" listed as items in the 1930 report are evidently included in the "Other Engineering" item of the 1923–1929 report, while "Engineering Electives," "Non-Engineering Electives" and "Miscellaneous" of the 1923–1929 report are doubtless all combined into the item of "Electives" in the 1930 report. The other subjects, however, listed side by side, appear to agree exactly.

The slight increase in English and economics with the corresponding decrease in modern foreign languages is notable. Still this does not show the full effect of the change, since some colleges still are revising their curricula in this respect. For example, the college of engineering at the University of Michigan will change its requirements as of September 1932, dropping 16 hours of foreign language or non-technical electives in favor of 4 additional hours required in English, 6 hours required in economics, and 6 hours of free non-technical electives.

It is believed, then, that a great improvement has been made in the preparatory and secondary parts of the curriculum in electrical engineering as a result of the foregoing study and discussion. Some glaring omissions have been remedied and some old ideas have given way to new and present conditions. The fact that the recommendations after careful analysis by the colleges have been so widely adopted shows how valuable the recommendations of the practising engineers have been, and how much they have achieved. We should expect, therefore, similar advantages to accrue from a study and discussion of the technical portion of our curriculum in something like the detail which was thus given to the preparatory and secondary subjects.

Technological Subjects

With regard to the technological portion of the curriculum in electrical engineering the tabulations of the total semester hours allotted to these subjects

in the major branch of electrical engineering itself, those in other engineering fields and those in engineering electives, in the 1923–1929 and 1930 S.P.E.E. reports, are given in Table II.

It is noted that while there has been an increase in the central core of subjects in electrical engineering itself from 34.4 to 39.0, still the electrical curriculum contains fewer technical courses in its own field than any of the other major curricula, particularly those of chemical and civil engineering with their respective requirements of 44.9 and 50 semester hours in their own major branch. It would appear, then, that the electrical engineering students take proportionately more of their technical work in associated departments and in electives, a situation which will heartily commend itself from the points of view of broad foundational training and freedom for the student to pursue his ambitions to at least a slight degree into some particular field of his own choice.

The tendency to increase the number of semester hours of technical requirements in electrical engineering was noted in the 1923–1929 S.P.E.E. report. That it prevailed and resulted in an 11 per cent increase is shown by the report for 1930. In view of the close approach to an upper limit, should we not examine how scientific the training of a 4-year electrical student should be? Doubtless we are all agreed that he must have as an absolute minimum, say, some 16 semester hours of fundamentals in d-c. and a-c. machinery and steady-state circuits. But in the light of modern developments and in preparation for some known problems of the future, how much further should we go?

The electrical engineers who were consulted in 1923–1929 as to which divisions of electrical engineering were of such importance as to warrant their inclusion in the training of all electrical students replied as shown in Table III. (It was taken for granted that a general foundation in the principles of electrical and magnetic units, laws, circuits, and machines would be required of course in every case.) In view of the developments of the past few years and of immediate future demands, surely the subject of electronics and vacuum tubes should be added to the list. Such a course should include an engineering approach to the theories of ionization, of the mechanisms of current flow and energy interchanges in ionized regions, and of thermionic, photoelectric, and other types of electron emission, as related to conducting gases at atmospheric and lower pressures. The study should cover thermionic vacuum tube characteristics and types of circuits and tubes suitable for rectifiers, amplifiers, detectors, and oscillators.

Table II—Semester Hours Required for Graduation in Different Courses

1923–1929		1930				
Subjects	Units	Subjects	E.E.	M.E.	C.E.	Ch.E.
Elec. Engg	34.4	Technological Major Branch	39.0	41.0	50.0	44.9
Other Engg	42.1	Other Technical Subjects	23.5	22.9	18.4	21.6
Engg. Electives	6.8	Electives	10.4	9.3	8.4	6.7
Grand Total	146.9	Grand Total	143.4	145.5	144.0	146.4
No. of Institutions	55	No. of Institutions	51	44	51	41

Analysis of College Curricula

Not all of the subjects in Table III are standard requirements in college curricula but nearly all are represented in the programs as requirements or available electives, the exception being perhaps electrochemical engineering which in practically every case is offered in the departments of chemistry. The study summarized in Table IV shows what a number of representative schools provide in required and elective courses in these subjects.

It is notable that there is great consistency in the first 4 columns of Table IV in that nearly all colleges require a group of fundamental courses of not less than 16 hours and also provide 1 or 2 courses in transmission and distribution, power plants, and electrical machine design. The few schools whose catalogs do not show a course in electrical power plants provide a strong preparation in the courses they schedule in the heat power division of mechanical engineering. There is also strong agreement in using the field of power plant engineering as the vehicle for applying economics to engineering problems. In the remaining columns for the electrical division of Table IV the courses offered are mainly elective, the restriction of time allowing the undergraduate student probably not more than 1, or at most 2, courses in any division. Many colleges offer several sequential electives in the various divisions, but the courses are principally for graduate students. There are difficulties in analyzing the curricula in these divisions. Illumination may be offered in some cases in the department of physics; telephony, telegraphy, radio, and electronics, may be combined in various ways in courses given as communication engineering.

Table III—Per Cent of Engineers Favoring Inclusion of Various Subjects

Per Cent	Subjects	Per Cent	Subjects
67.5	Transmission and distribution	33.5	Illumination
59.0	Power plant engineering	33.2	Electrochemical engineering
57.0	Electric machine design	28.4	Electric railways
44.0	Industrial power engineering	22.5	Telephony-telegraphy
38.8	Hydroelectric engineering	19.5	Radio engineering

Related Engineering Subjects

In order that the preparation shall have a proper breadth, and that the graduate shall understand something of the problems facing his colleagues, what should be the training of electrical students in the fields of the associated technical departments of mechanical, chemical, and civil engineering?

In mechanical engineering the electrical student has need of a fundamental course dealing in elementary thermodynamics, steam, fuels, boilers, steam

Table IV—Required Semester Hours for Students of Electrical Engineering—1931

me of Institution	Electrical Divisions											Mechanical			Civil				Chemical
	Fundamental Courses	Trans. and Dist.	Power Plants	Elec. Mach. Design	Industrial Power	Illumination	Electrochem.	Elec. Ry.	Tel. and Tel.	Radio	Electronics	Heat Power	Machine Design	Shop	Structural Design	Hydraulics	Surveying	Railway	Engineering Materials
abama Pol	24	5	8	4e	4e	2e			6e	6e		10		4		3	3		2
mour Inst	34	4.5	4.5		2							9	4	6		4	1.5		1
ooklyn Pol. Inst	18	3		2		2		2	5	2		9	1	2	2	3			1
iv. of Cal	18	5	4	3e					5	6e		9	2	4		6	6		
rnegie Inst	33	2	5	9					2	3				7		3	2		4
se School	27	5	1		3e	6		1	3		3e	7	3	2		3	3		1
rnell Univ	33	3e	3	4e	2e	2e		2e	4e	3		11	4	4		2	3		6
orgia Tech	24	3	5e	2		3e		5e	2	3e	3	8		3		4	2		2
rvard Univ	16	7		3e					3e	3e	3	8	4	1		3			4
iv. of Ill	22	3e	4	2		1e				6e		11		6		3			
iv. of Iowa	22	6e	5e	3		3e			6e	3e		5		3		2	3		
wa State	24	2	2	2e				2e	2	2e		8		4		3	2		2
hns Hopkins	30	2.5	2.5	4		2.5		2 5		5		13				3	3		3
iv. of Kansas	15.5	4	3		3e	2.5		2e	5e			6.5	3	4		3	3		1
nsas State Ag	26	3e		3		3e			3	3e	1e	9	3	5		4	2		2
high Univ	25	6e	3	6e	2e			3e	3e	3e		8				3	4		3
iv. of Maine	27	3	3	3		3		3	4.5	4.5		7.5		3					
ass. Inst. Tech	19	5	6e	6e	3e	3e		6e	3e	3e		8		3		3	2		
iv. of Mich	16	4	5	4	2e	2		2e	4e	6e	4	4	3	2	3	3	2		3
iv. of Minn	27	4e	6e	4	2e	4e		2e	6e	6e	2e	6		5		3			
iv. of Nebraska	22	4e	4e			2e		3e	4e	3e		7	6e	6e		3e	6e		
io State Univ	20	2e	2e	4e		4e		3e	6e	3e	2	6	6	6		2			
nn. State College	20	5e	2e	2e	2e	2		3e	3e	2e		10	4	4		2	1		2
iv. of Pittsburgh	17.5	3	2	2	4	3		2	1.5	1.5		5	4	1		2	2		
inceton Univ	16	2	3e	6	2e		4e	2e				10	3			3	2		2
rdue Univ	26	6e	6e	5	3e	3e		3e	6e	6e	6e	7		4		4e	2e		
nss. Pol. Inst	21	4	3	4	2	2	3	2	1.5	1.5	3	9	2	8	3	4	2	3	1
xas A. & M	32	3	3	6e	3e	3e			3e	3e		8		2		3e	2		
ion College	28			3								6				3	6		
rginia Pol. Inst	18	6e	6	3						6e		6		6		3	2		
ashington State	23	5	2e	2		3e		3	3		3e	9	2	4		3	3		4
iv. of Wisconsin	24	6	3	3		3e			3e	6e	3e	9	3	4		3	3e		2
le Univ	32	3e	3e		3e				3e	3e	3e	6					3		2

= elective.

ngines and turbines, condensers, internal combus-on engines, and the general problem of a power lant. Some time in steam laboratory would be aluable to vitalize the work. It will be necessary to stablish the standard ratings, efficiencies, methods f governing, and speed regulation of the prime iovers here so that they may be transferred to the lectrical courses concerned with the generator.

To chemical engineering we look for a knowledge of ie engineering materials with which to work. For eneral structural and power work every student eeds an elementary knowledge of the manufacture nd properties of the ferrous and non-ferrous alloys, ements, clay products, protective coatings, fuels, oiler scale, and water softening, together with ssociated laboratory experience in mechanical work-ig and heat treatment of the various metals, welding ractise, protection against corrosion, etc. In addi-on to these widely used materials which are gener-lly covered in the common introductory course in iemical engineering, the electrical student has a oecial interest in the silicon steels, in oils and papers, i cold and hot flow materials, in phenol plastics, arnishes, tapes, and mica. Seemingly no course iven at the present time covers these materials hich are so essential to the electrical designer. hey should be included in the more comprehensive st of fundamental materials for an electrical student.

In civil engineering a common basic structural esign course may follow some 8 semester hours of igineering mechanics, or the same field may be overed as applied mechanics in the last named department. At the University of Michigan the preparatory design courses in mechanics cover statics, 3 hours; strength and elasticity of materials, 4 hours; laboratory in strength of materials, 1 hour; and dynamics, 3 hours. In a fundamental structural design course we feel that the student should have some elementary training in analysis of stresses, moments and shear, for wood, steel and concrete beams, roof trusses and columns; beams and slabs in reinforced concrete masonry; and introduction to soil bearing theory, bearing power of piling and settlement, together with some contact with electric welding of frames and machine structures.

For curricula in electrical engineering, the semester hours required in cognate or related engineering subjects are shown in the right hand side of Table IV. While there is almost general agreement as to the necessity for courses in heat power, shop work, and hydraulics, there is evidently a considerable difference of opinion as to the need for training in surveying and in the mechanical features of machine design. Again, almost half of the programs offer no training in engineering materials and only 3 curricula call for a structural design course after a preparation in engineering mechanics.

In view of these differences of opinion among teachers not only as to the subjects to be included in the fundamental training of the student but as to the time spent upon them as well, it is felt that considera-tion and study and the gathering of suggestions from the practising members of our profession would be very much worth while.

Control for 3,000-Volt Multiple Unit Cars

Because of the relatively high voltage used and the necessity of mounting the apparatus in a limited space, many new problems of control design were encountered in the 3,000-volt d-c. suburban electrification of the Lackawanna Railroad. This article describes the construction and operation of some of the more important of the control apparatus developed, and the tests made to assure its suitability to the service for which it was designed.

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THE 282 CARS on the Delaware, Lackawanna and Western suburban electrified system are arranged to operate as 141 units, each unit consisting of 1 motor car and 1 trail car semi-permanently connected; each motor car has 4 1,500/3,000-volt motors of 235 hp. hourly rating, 2 motors being permanently connected in series. Operating stations are provided at each end of each 2-car unit, 1 on the motor car and 1 on the trail car. Trains are made up of from 1 unit (2 cars) to 6 units (12 cars). The auxiliary control of these cars has been described previously ("Auxiliaries for High Voltage D-C. Multiple Unit Cars," by C. J. Axtell, A.I.E.E. TRANS., v. 49, 1930, p. 1282–6); hence this article will treat only features of the control for the traction motors.

Motor control is of the pneumatically operated cam type with automatic acceleration at the rate of 1.5 miles per hr. per sec. The following control points or steps are provided:

6 accelerating steps with 4 motors in series.
1 running step with 4 motors in series.
5 accelerating steps with 4 motors in series-parallel.
1 running step with 4 motors in series-parallel, full field.
1 running step with 4 motors in series-parallel, shunted field.

The control equipment normally operates with a constant air pressure of 70 lb. but will function satisfactorily at a minimum pressure of 50 lb.

A schematic wiring diagram of this motor and control circuit is shown in Fig. 1. A motor generator set and a 300-ampere-hr. battery furnish power at 32 volts for control, lights, and auxiliary circuits; the control equipment is designed, however, to operate over a range of from 20 to 45 volts. Table I gives a listing and weights of the major parts of the control equipment.

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

Table I—Weight of Control Equipment of Lackawanna 3,000-Volt Multiple Unit Cars

Equipment	Weight in Lb.
2 pantographs	2,270
8 pantograph insulators	340
1 main fuse in box	151
1 main switch and auxiliary fuse box	313
1 line breaker	583
1 motor controller	1,119
1 set motor resistors	455
1 field control switch	88
2 inductive field shunts	1,340
1 master controller	75
Total weight of motor car control including dynamotor and field shunts	11,950
Trail car control equipment	1,260
Total weight of control for 2-car unit	13,210

CURRENT COLLECTORS

Current for each unit is collected from the double or twin contact wire by a pantograph trolley on each motor car. Pantographs are of the spring-raised air-lowered type, with:

1. Maximum working range .... 10 ft. 6 in.
2. Length of contact surface .... 4 ft. 0 in.
3. Vertical movement of collector shoe .... 2 in

Bearings on the main shaft are taper roller self-aligning, with pressure lubrication. Contact pressure of the shoes against the wire can be adjusted from 20 to 35 lb. with a maximum difference of 6 lb. between the pressure exerted with the pantograph going up and that exerted with trolley retracting.

MAIN FUSE

All wiring and apparatus on the car, except the trolleys, is protected by a compression type main fuse mounted on the car roof (see Fig. 2). The fuse holder has two expansion chambers joined by an insulating tube; the fuse consists of 2 braided copper leads with a connecting link of fusible alloy. The vaporizing of the fusible link creates pressure within the tube; this expels the braided copper leads from the tube and extinguishes the arc quickly, without any noise or flame that can be detected.

Arc rupturing tests were made on this fuse with both inductive loads and short circuits on a 3,000-volt 3,000-kw. motor-generator set built especially for high current testing. From oscillograph tests the times required to extinguish the arc completely after the fuse had melted were as follows:

Volts	Amperes	Circuit	Time (Sec.)
3,000	3,040	Inductive	0.030
3,000	7,000	Non-inductive	0.0076

The oscillograph record of the first test is shown in Fig. 3.

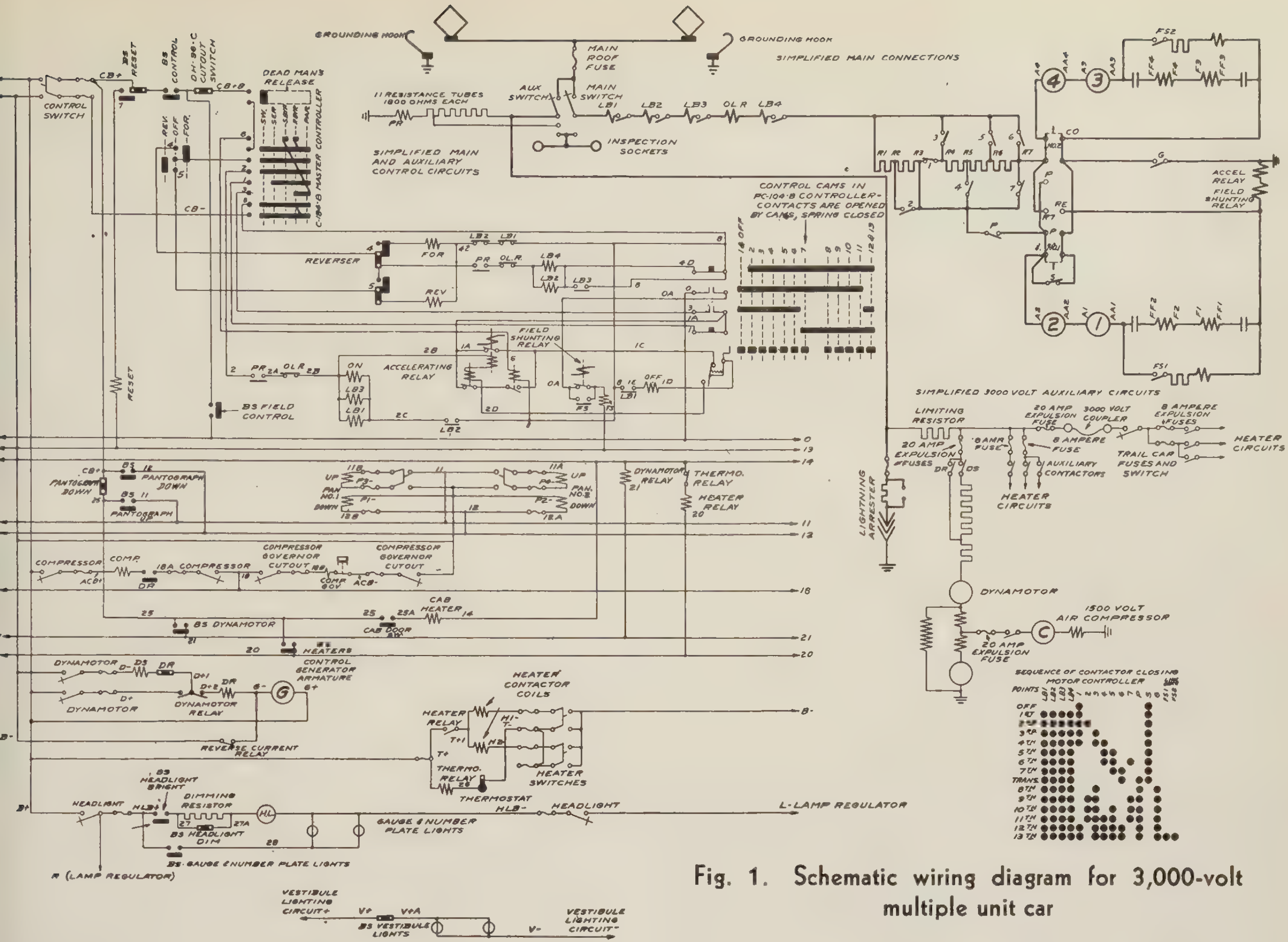

Fig. 1. Schematic wiring diagram for 3,000-volt multiple unit car

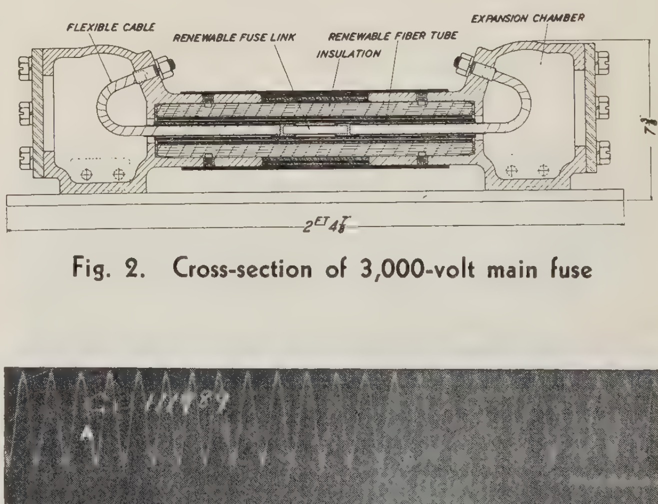

Fig. 2. Cross-section of 3,000-volt main fuse

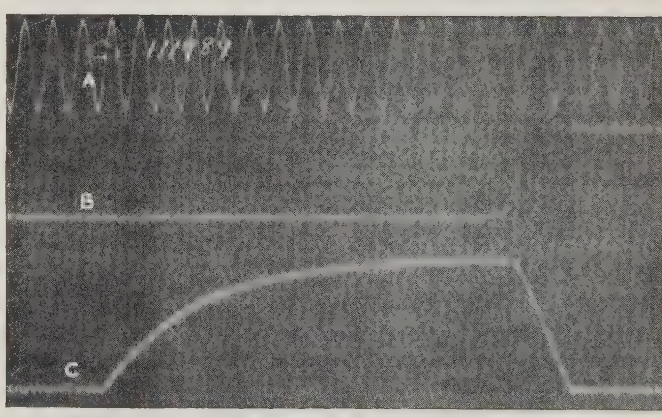

Fig. 3. Oscillograph record of 3,000-volt main fuse rupturing 3,040-ampere inductive circuit

A—60-cycle timing wave; B—Line voltage; C—Line current

INE BREAKERS

On these equipments the line breaker is the only evice that cuts off the power to the motors; conseuently 4 3,000-volt contactors are used in series rupture normal as well as overload currents. rom the standpoint of safety it is essential to have circuit rupturing devices controlled from individual ain wires, each device capable of opening the motor rcuit; consequently 4 contactors connected in series e used although 2 will interrupt any overload curnt. The contactors have a nominal capacity of 50 amperes with the blowout coil decreased to 200mpere capacity to increase the number of turns; the nits have $^3/_4$-in. wide tips and a tip gap of 1 in. he contact tip pressure is 70 lb. An overload relay mounted directly on the back of the No. 4 conctor as shown in Fig. 4.

Oscillograph records made when testing the current upturing capacity of this breaker show the following mes to rupture the circuit after the contact tips egin to part:

Test No.	Contactors Breaking Circuit	Volts	Amperes	Load	Time Sec.
1	2	3,000	4,500	Non-inductive	0.017
2	2	3,000	700	Inductive	0.025
3	4	3,000	1,500	Inductive	0.043
4	2	3,000	1,500	Inductive	0.074

The oscillograph record of test 3 is shown in Fig. 5. Interruption tests were made with 2 contactors in series with the following results:

10 interruptions in 2 min. with 3,300-volt 1,500-ampere inductive load.

5 interruptions in 2 min. with 3,300-volt 3,000-ampere non-inductive load.

On account of the liberal design of the line breaker contactors the heating for the service in which they are used is very low. A continuous heat run at 270 amperes gave the following temperatures:

Blowout coil	84 deg. cent. rise
Contact tips	45 deg. cent. rise
Flexible shunts	38 deg. cent. rise
Magnet valve coil (operating at 40 volts)	30 deg. cent. rise

The line breaker, because of the high voltage circuit and its location on the car, was designed to be grounded to insure safety to any passenger or workman who might come in contact with the box. Grounding this box necessitated some radical changes in insulation and box construction quite different from previous designs on which it has been customary to insulate the enclosing cases.

Motor Controller and Associated Equipment

The motor controller, consisting of a group of devices assembled in a box for mounting underneath the car, is the principal part of the motor control apparatus. The box is made of fabricated steel with welded joints. Top covers are fixed and all side and end covers are hinged and latched. Cables enter the box at the top through 2-piece wood cleats. The equipment is mounted underneath the car with the box grounded to the car underframe.

A view of the front of the motor controller with the arc chutes of the cam contactors removed is presented in Fig. 6; at the right are the motor cutout switches and on the left are mounted the main air engine and relays. This motor controller contains:

7 cam operated resistance contactors.
3 cam operated contactors for series-paralleling the motor group.
1 main air engine for operating the cam shaft.
1 motor reverser.
2 motor cutout switches.
1 potential or no-voltage relay.
1 accelerating relay.
1 field control relay.

The cam contactors, one of which is shown in Fig. 7, have current carrying parts clamped on a rectangular steel bar which is covered by wrapped insulation. All contactors have magnetic blowout. Current carrying parts are of brass and both upper and lower contact tips are provided with arcing horns. Individual arc chutes can be removed by loosening a single screw at the top of the contactor and rotating the locking mechanism.

Contactors are closed by cams bearing upon a steel roller; they are opened by the pressure of the contact spring and by gravity. Should a contactor tip stick or "freeze," a mechanically operated "knock-out" operates on the cam shaft and mechanically forces the contactor open. Contactors have a 1-in. tip gap and renewable contact tips $^{3}/_{4}$ in. wide; contact tip pressure is 16 lb. Two of the contactors (R6 and S in Fig. 1) have enlarged arc chutes vented to the outside of the box as these contactors under some conditions are required to break current. The cam shaft is of hexagonal steel with wrapped mica insulation, cast iron cams being clamped on over the insulation and separated by insulating collars.

An opposed-cylinder air engine operates the cam shaft through a rack and pinion. Air admitted to the "on" cylinder rotates the cam shaft to the "on" position while air admitted to the "off" cylinder stops the progression on any step. Admission of air to the "off" cylinder is governed by a magnet valve under control of the accelerating relay which permits the cam shaft to rotate step by step under the influence of the current through the motors; this maintains a constant average current during acceleration. A specially designed accelerating relay also provides means to enable the operator to advance the motor controller one step at a time regardless of the motor current.

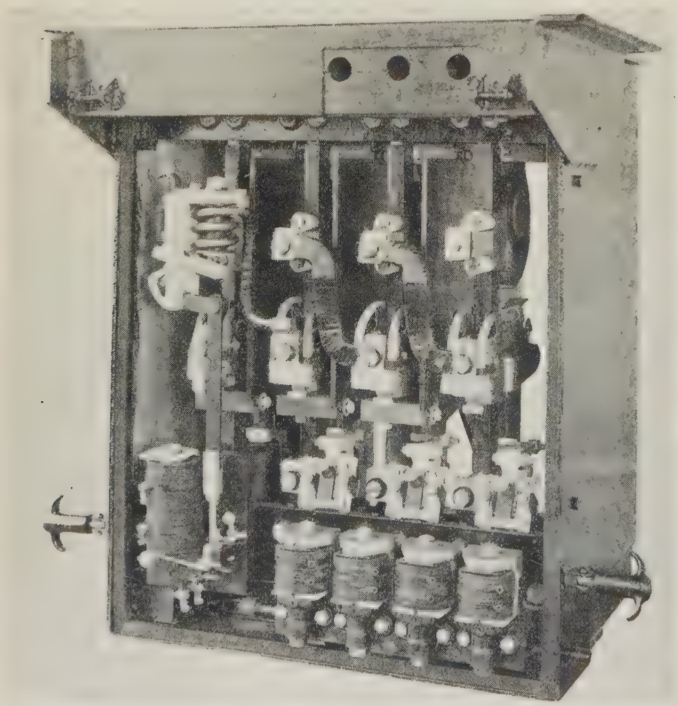

Fig. 4. Rear view of 3,000-volt line breaker

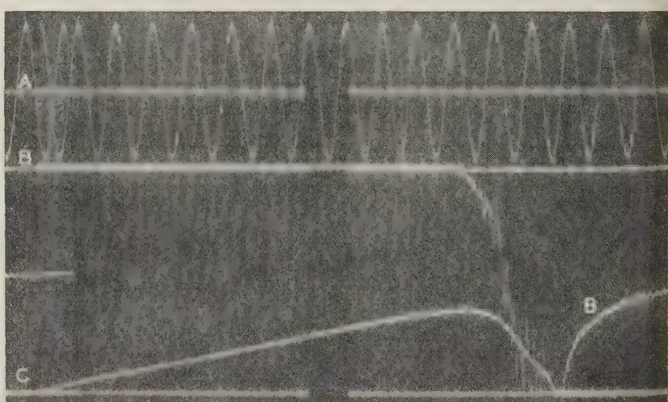

Fig. 5. Oscillograph record of 3,000-volt line breaker rupturing 1,500 ampere inductive circuit

A—60-cycle timing wave; B—Line voltage; C—Line current

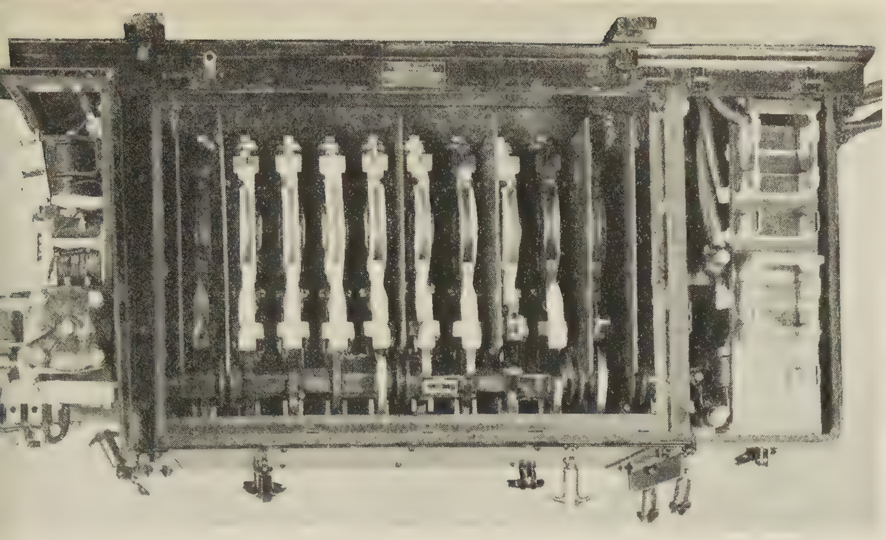

Fig. 6. Front view of motor controller with contactor arc chutes removed

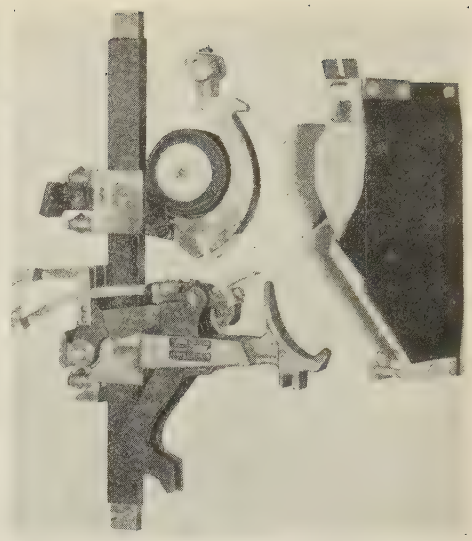

Fig. 7. Cam operated 3,000-volt contactor

Field connections of the motors are reversed by an lectropneumatic reverser mounted in one end of the notor controller. It is of the cylinder type with egment castings mounted on an insulated hexagonal haft. A double cylinder air engine furnishes power o rotate the cylinder to either the forward or the everse position.

In addition to the accelerating relay there are rovided (1) a second relay to govern the closing of ne field control switches, and (2) a potential relay rith resistor tubes to cut off the control current on an ndividual car should the line potential fail. The otential relay closes at 1,300 volts and opens if the otential falls to 750 volts.

FIELD STRENGTH REDUCED BY INDUCTIVE SHUNTS

The fields of the motors are shunted by an inducve shunt giving a reduced field strength of 50 per ent. In series with the inductive shunt is an adıstable non-inductive resistance to compensate for ny variation in the wiring of the 2 pairs of motors. separate box with 2 contactors operated by a single ir cylinder and having mounted in the back 2 adıstable rheostats composed of edgewise wound units omprise the equipment for shunting the fields.

Main resistors are of the edgewise wound type rranged in 1 group of 2 sections, and 1 group of 3 ections. All of the resistance is connected in the rcuit on the trolley side of the motors. The alloy f which the resistors are wound has a high specific esistance, 120×10^{-6} ohms per cm.[3], but a low emperature coefficient of resistance; the increase in esistance is 5.8 per cent with 350 deg. cent. rise in emperature. The resistor frames are insulated from ne support by 1,500-volt porcelain bolt insulators; ne support is insulated from the car framework by 000-volt porcelain bolt insulators.

IASTER CONTROLLER AND CAB EQUIPMENT

The master controller has 2 cylinders, a main and reverse. A "dead man's release and emergency

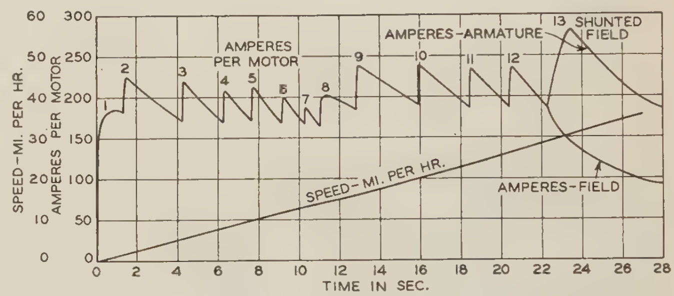

Fig. 8. Acceleration curve of Lackawanna 3,000-volt d-c. multiple unit cars

brake feature" is incorporated in the controller which interrupts the control current and actuates a pilot valve to apply the emergency air brakes should the handle be released.

A button type switch in each cab gives the operator convenient control over the pantographs, control equipment, overload reset, dynamotor, heaters, and lights. It is provided with a lock so arranged that all important circuit switches are locked in a fixed position when the key is removed. An additional control switch is connected to the air brake cutout cock; this switch cuts off all control current to the master controller unless the cutout cock is open, thus preventing the starting of the train until the air brakes have been cut in.

TESTS

A sample unit consisting of a motor car and a trail car was completely equipped with motors, control, and air brakes, for test purposes. These cars were run for 15,000 miles on the 3,000-volt test track at Erie, Pa., to determine how they would perform under service conditions.

The production control apparatus was subjected to many special tests. In addition, all control devices for 3,000-volt circuits were given a high potential test of 8,750 volts at 60 cycles for 1 min.; all control devices for the 32-volt circuits were tested at 1,000 volts, 60 cycles for 1 min.

Sectionalizing Improves Rectifier Efficiency

By building large capacity mercury arc rectifiers from a group of several small sections, the better efficiency, reliability, economy, and flexibility inherent in the smaller rectifiers can be retained in the larger units. Experiments on a 3,000-kw. rectifier composed of 4 750-kw. units, shows an efficiency one per cent higher than for the conventional single unit type.

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PRACTICABILITY of the sectional type of mercury arc rectifier is based upon the obvious, but apparently heretofore unrecognized, fact that the best possibilities inherent in the device are realized only in the smaller sizes. Efficiency, reliability, economy, and flexibility of both application and use are all far better in small than in large units. Furthermore, the advantages appear to be fundamental and therefore permanent. Subdividing a mercury arc rectifier into unit sections introduces both advantages and disadvantages; but the advantages so far outweigh the disadvantages that, once the conception is considered seriously and the sectional design actually worked out, doubts disappear and sectionalized plan seems the right and natural one to adopt.

Development through the past 29 years has resulted in rectifiers of small capacity, 500 kw. for example, with a high degree of reliability, a reasonable cost, and an efficiency which makes available for the higher voltage applications the unique quietness and freedom from mechanical wear which has been the major incentive throughout the development. When size is increased, however, the quality decreases markedly. Reliability decreases not in proportion to size, but more rapidly because the difficulty of controlling the "hurricane" flow of vapor from the cathode is increased enormously when the size is even doubled. The outage time of 3,000-kw. rectifiers is several times as great as that of 500-kw. units. Cost per unit output does not decrease with increase of size, as it does with some apparatus; this is because manufacturing problems increase faster than in proportion to size, and because the total requirement for this kind of equipment with capabilities and limitations as they are even in the smaller sizes, will not support organized "line manufacture" for the larger capacities. Efficiency falls off with increase in size because of the longer arc and greater exposure to deionizing surfaces, and because to obtain acceptable quantity the fundamentally less reliability makes necessary an increase in loss-producing arc-back preventives. With present designs, internal losses per unit output for a 500-kw. rectifier are only about $^3/_4$ of those for a 3,000-kw. unit, both based upon 600-volt operation.

Disadvantages of Large Units Fundamental

The major disadvantages which go with size appear to be fundamental and permanent, whatever advances may be made. Larger units always will be less efficient, and the reliability and cost disadvantages probably will persist.

Multiple installations of conventional small capacity units of the sort available in the past are impracticable; the space required is too great and the multiplicity of control and protective devices appears highly undesirable. But if a rectifier of large capacity is subdivided so as to take advantage of space economies resulting from recent advances in the art, building the structure in sections but installing, controlling, protecting and using it as a whole, the project becomes feasible; the desirable qualities of the small rectifier are made available for the larger capacities while the disadvantages of sectionalizing are reduced so as to become negligible.

Research in the Westinghouse laboratories on rectifiers of conventional size and characteristics has shown that the limitation in capacity for a given design lies in local limitations of the various parts, for example, the limits of conductivity and heating at the anode, and not in the fundamental and perhaps more troublesome tendency to arc back at the higher currents. To illustrate this the 500-kw. rectifier shown in Fig. 1 carries a nominal current of 833 amperes continuously, 1,250 amperes for 2 hr., and 2,500 amperes for 1 min.; extensive tests, which include use at currents up to 17,000 amperes on short circuit and loads of 2,000 to 2,500 amperes for periods of 5 to 30 min., depending on temperature rise, have not shown arc-back to be a limitation. Extended service experience with a limited number of installations gives the same result. Evidently, changes in the details leaving the general arrangement unaltered, would make it possible to reduce materially the size of the containing tank without affecting the ability of the unit to carry the loads required. Experiments have verified this conclusion.

Size Reduced by Rearranging Parts

As a further step, a rearrangement of parts made possible a still further reduction in size for a given rating, and at the same time brought about some reduction in the internal losses. The rearrangement was based upon knowledge gained from experiments made to determine: (1) the effect of the way the vapor flows from cathode to condensing wall; and

Based upon "High Capacity Rectifier Efficiency Improves by Sectionalizing" (No. 32-50) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

2) the effect of the position of the anode structures n relation to this stream of ionized vapor upon the miting current of which the rectifier unit is capable ithout excessive arcing-back. Although the whole echanism of vapor flow and its effect on arc-back till are obscure, several factors that influence erformance have been established. In the design nown in Fig. 2 an attempt has been made to take nto account in the most satisfactory way possible t the present time, these as yet rather intangible nd, it must be admitted, somewhat uncertain ctors.

The desirability of improving the anode support nd shielding arrangement also offered an opportuity for progress; a rather extended series of experiments resulted finally in the anode structure shown n Fig. 2. Processing to eliminate foreign material nd to keep the gas evolution in operation at as low value as possible, have progressed along with the esign development.

As a result of these improvements, the rectifier ection shown in Fig. 2 is capable, with a reasonable argin, of a standard nominal rating of 750 kw. t 600 volts, and of even higher short-time overloads t this rating. The unit is required to carry a ormal current of 1,250 amperes, and 50 per cent verload, or 1,875 amperes for 2 hr. Since final emperatures are reached in about 2 hr., it is felt hat the 2 hr. capacity can best be indicated by ontinuous operation at the 50-per cent overload alue; experimental tests have been made in this ay, thus including in a single test some margin of afety along with a degree of acceleration of the est. Double load, or 2,500 amperes, is required by tandard nominal rating for a period of 1 min. ollowing full load; experimental tests have been ade at this current for a duration as long as 5 min. n all these operations, arc-back is quite infrequent; rthermore, it is a requirement that the rectifier an be put into operation again immediately following such an occurrence.

Arc-Drop Lower in Sectionalized Rectifiers

Internal losses in the rectifier are determined by the arc-drop, or voltage from anode to cathode during the conducting period; this voltage varies with load current. The value that determines the rectifier efficiency is the average for the various anodes. Fig. 3 shows an average arc-drop curve for both the unit indicated by Fig. 2 and the older, conventional unit shown in Fig. 1. As the size of a rectifier is increased, the arc path becomes longer, resulting in increased exposure to deionizing surfaces; thus the losses per unit output become greater. Experimental rectifiers of 3,000 kw. with a single tank have had arc-drop voltages as shown by the dot-dash curve of Fig. 3. It may be seen that at full loads the difference between the arc-drop voltage of these experimental single-tank 3,000-kw. rectifiers and that of the sectional units shown in Fig. 2 amounts at full load to approximately 6 volts or 1 per cent, on the basis of a 600-volt output. With ordinary load factors and power costs, a 3,000-kw. sectionalized rectifier thus could be operated for from $600 to $1,500 less per year in power cost than could a single-unit rectifier of this capacity; this saving would justify an added investment of from $4,000 to $10,000.

Physical proportions of the sectional units are such as to make it feasible to mount them in service one above another. Thus, a 3,000-kw. unit can be made of 4 750-kw. sections mounted 2 side by side and 2 high, as shown in Fig. 4. Floor space required for such an assembly is approximately 118 in. wide, by 68 in. deep, overall, including auxiliary equipment. The over-all height is 113 in. and the necessary ceiling height of a room to accommodate this equipment need not exceed this value except for electrical clearance of a few inches and whatever may be necessary to provide for adequate working space, certainly not more than 2 ft. It is evident that the sectionalized plan thus makes possible a

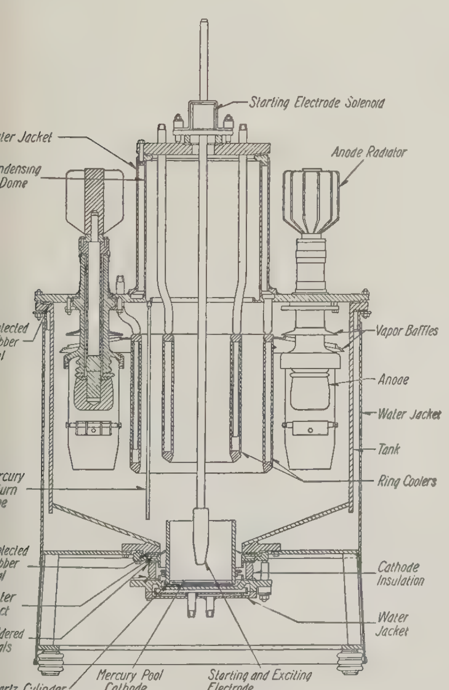

Fig. 1. (Left) Sectional view of a conventional 500-kw. 600-volt rectifier

The diameter of each of the 2 units is 54 in.; over-all height of the conventional rectifier shown on the left is 104 in. while that for sectional unit shown on the right is 41.5 in. The kw. rating per unit volume for the sectional unit is thus more than 3 times as great as for the conventional unit

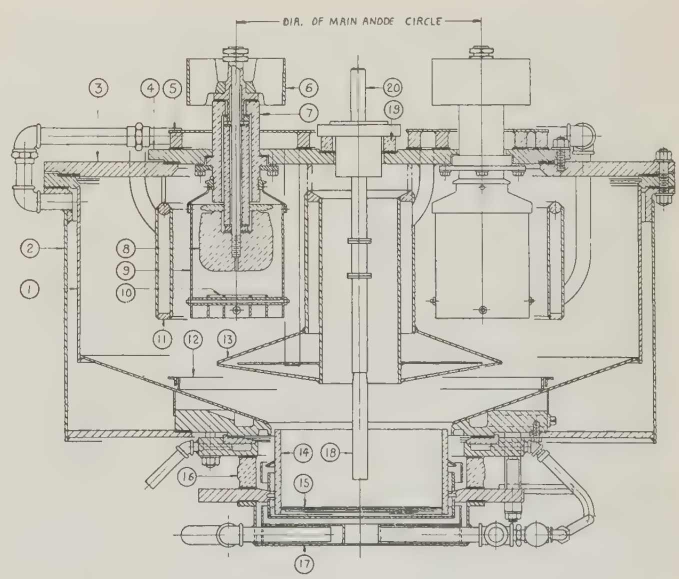

Fig. 2. Sectional view of an improved 750-kw. 600-volt rectifier unit

considerable saving in space. Such an arrangement is likely to prove the most convenient for usual applications. There is no reason, however, why other arrangements cannot be used where available space places a limitation on one or more dimensions.

Paralleling Sections No New Problem

The problem of paralleling is the same for sectional rectifier units as for a single tank rectifier using the same number of anodes and, except in detail, is the same for any rectifier using twelve or more anodes. Load balancing is inherently approximately correct because the voltage across the arc rises with increasing current after a minimum at about 40 per cent load. To get a closer balance, anode balancing coils are used; these are arranged so as to introduce no appreciable impedance into the circuit under normal operation. Should it be desired to take a section out of service, for maintenance or any other reason, the corresponding balancing coil sections are short circuited by connecting links provided for the purpose.

One arrangement of vacuum pumping for sectional units is indicated in Fig. 5. Use is made of 2 independent pumping systems, connected through manifolding to the various sections and with cross connections so arranged as to permit the use of either pumping system or any or all of the tanks. The various sections of the rectifier are connected to the vacuum manifold through 2 valves of unique design, provided with a sealing plate as an extra precaution against outside air. Even if such a valve should develop a leak, this safeguard would prevent any leakage into the tanks except at a slow rate and only for the minute or less while the valve position is being changed. The use of 2 valves permits the separation of a single section from the balance of the structure without admitting air to either part. When maintenance work is required, it is thus possible to put the repaired section in condition by pretreatment, then install it and, by proper manipulation of the valves, exhaust it completely without admitting air to either the unit or any part of the operating system. With the pumping arrangement shown, this requires the operation of one of the other units with valves closed for some time. This introduces no further difficulty, however, for experience has indicated that if properly made and treated out the rectifier unit will carry normal loads without pumping for several hours or even several days without damage.

Sectionalizing inherently provides the utility

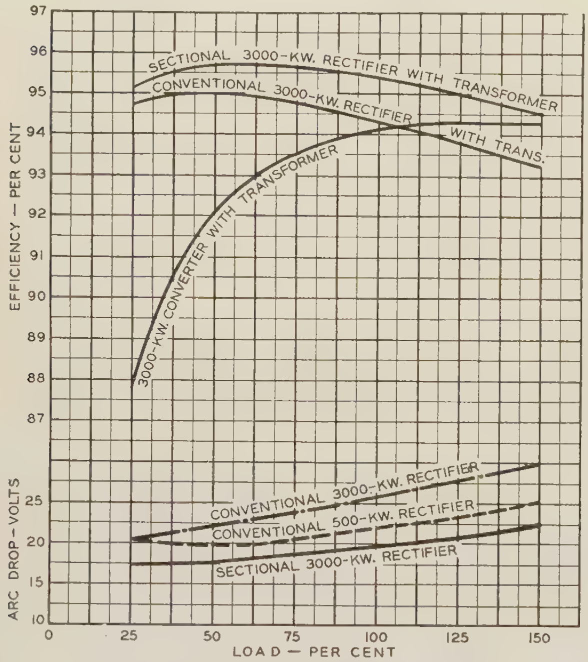

Fig. 3. Comparative characteristic curves for single unit and sectional rectifiers

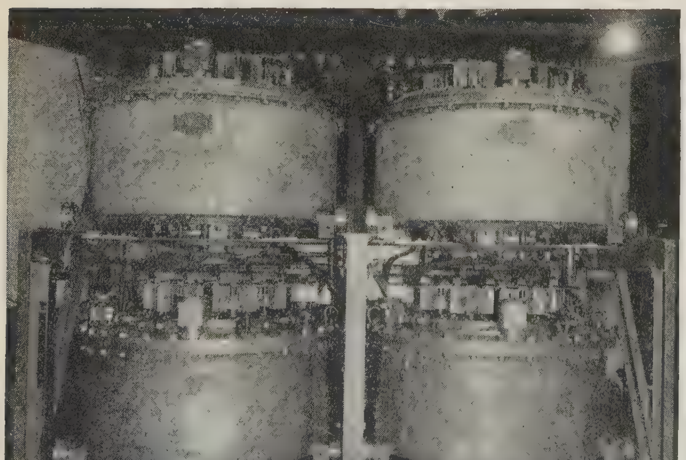

Fig. 4. A 3,000-kw. sectional rectifier composed of 4 750-kw. units

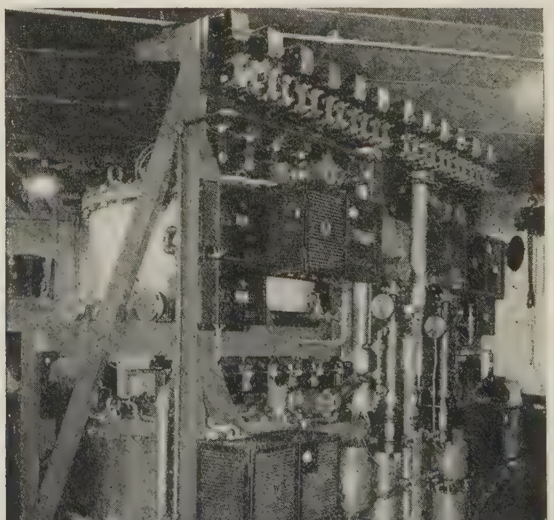

Fig. 5. Rear view of 3,000-kw. 600-volt 4-unit sectional rectifier showing arrangement for maintaining the vacuum

hat any damage is likely to be limited to a relatively small part of the total assembly and that during the period of maintenance the load can be carried by the remaining units. With the arrangement shown in Fig. 5, a faulty section can be segregated from the others by removing the connecting links and closing the valves, requiring only a few minutes, before load can be carried again. Although the maintenance operation to remove a unit from the structure for repairs requires as long as 2 hr. or more, this can be done during a light or no load period. It would be possible to arrange with jack connections and separate systems of auxiliary equipment or flexible pumping and water connections, so that the operator could pull the unit forward a few inches and go on with operation with the remainder of the equipment after an interruption of 1 or 2 min. Choice between these 2 plans depends upon cost and service requirements.

The sectionalized plan applied to mercury arc rectifiers, together with development work already performed in designing improved sectional units of more suitable dimensions and proportions, have made available in this equipment increased reliability, increased flexibility in application and use, improvement in manufacturing requirements, and an efficiency advantage of one per cent or more. Beyond this is the belief that further improvements will be made as time goes on and as a clearer understanding is acquired of the fundamental knowledge gained from research. It is to be expected that future developments will progress along the lines of sectional structures rather than single unit arrangements.

An Improved Gap for Station Apparatus

An improved voltage limiting gap for protecting electric power station apparatus has been developed, the breakdown characteristics of which may be varied over a wide range so as to conform to the characteristics of the station insulation. For the best protection, a lightning arrester in parallel with the gap is recommended.

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RECORDS as well as operating experience show that electric power stations may be subjected to a wide variety of transients. Although in practise it is necessary to limit the magnitude of the transients which may cause damage to the equipment, it is desirable that any limiting device shall not function unnecessarily, thereby causing interruptions. This is particularly true where a protecting gap is used that has not the ability to clear the line or prevent the flow of normal frequency current following discharge. This leads to the use of a limiting gap of relatively small time lag for transients of extremely high magnitude and steep front, in parallel with an arrester of greater time lag that will function for the many transients of lower magnitude without interrupting service.

It is exceedingly difficult to coordinate station insulation for the wide range of transients likely to be imposed, as the impulse flashover characteristics may be quite different as regards time lag and polarity, even though these characteristics be in close agreement at normal frequency. This is evident by reference to Fig. 1.

Owing to difference in time lag, a high overpotential suddenly applied may cause one type of insulator to flashover, whereas a transient having a much lower crest value may cause another insulator to flashover. Furthermore, the difference between the

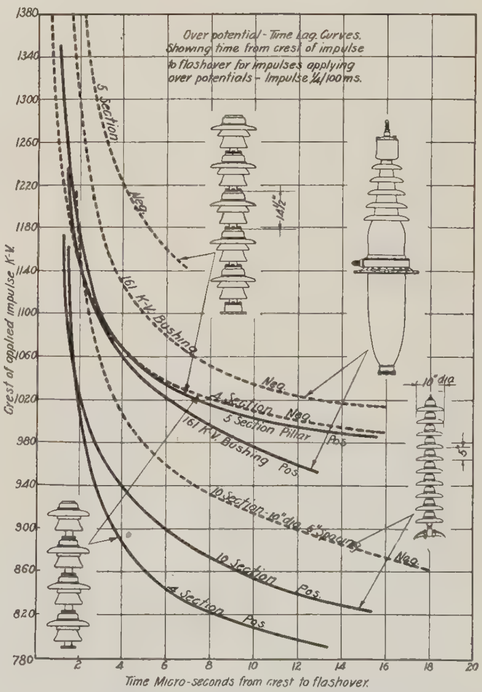


Fig. 1. Impulse flashover characteristics for different types of insulators

Based upon "Improved Type of Limiting Gap for Protecting Station Apparatus" (No. 32-60) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

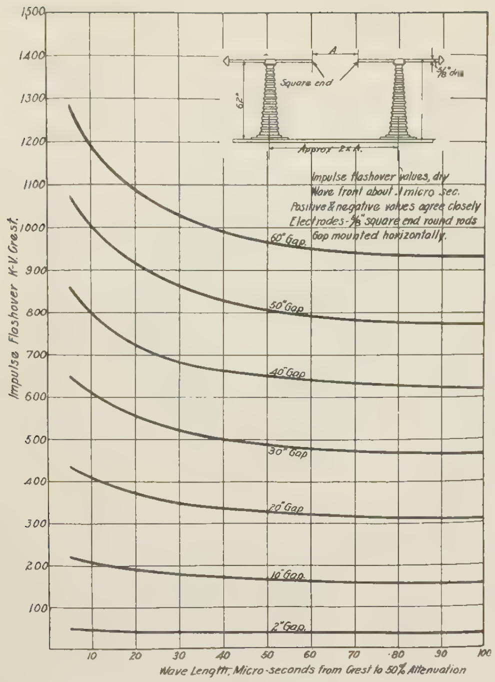


Fig. 2. (Left) Impulse flashover characteristics for a simple type of gap

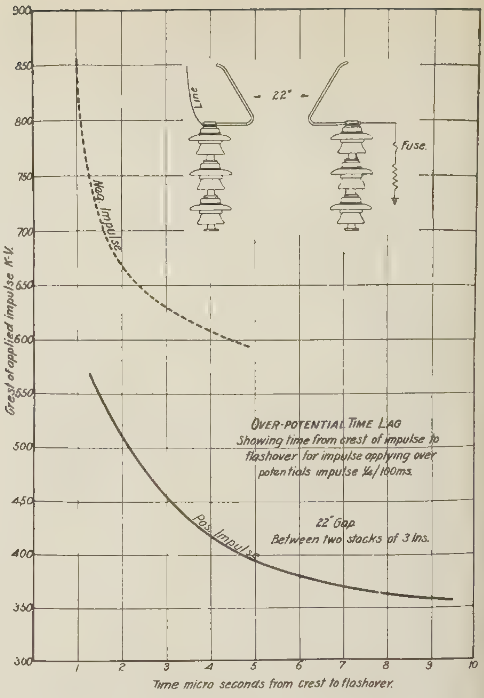


Fig. 3. (Right) Positive and negative impulse flashover characteristics for a typical horn-gap

breakdown voltage for negative and positive transients, respectively, may be quite large for bushings, bus insulators, and the internal insulation of transformers and circuit breakers. A bus insulation or a disconnecting switch may have a high effective flashover voltage for a negative impulse, and a much lower value for a positive impulse; for some other piece of equipment the reverse may be true. In station insulation therefore it is necessary to take into account not only the time lag in flashover, but the effect of polarity and oscillations as well.

A lightning arrester or a limiting gap which will protect station insulation against overvoltage transients long has been regarded of great economic importance. It is evident that if a gap or lightning arrester may be depended upon to protect the insulation in a manner similar to that in which a safety valve protects a boiler, it is possible to lower the level of insulation and thereby effect a material saving. To be fully effective, however, the limiting device must interrupt the discharge when the overvoltage is relieved, without interfering with operation.

Characteristics of Limiting Gaps

Impulse flashover voltages for a simple type of gap formed by two $^5/_8$-in. rods are shown in Fig. 2; Fig. 3 shows the time lag characteristics for a 22-in. horn-gap. In considering the characteristics of these gaps, it may be noted that the flashover voltage tends to increase rapidly for short waves or for short time intervals. Since equipment needs protection most for severe direct strokes at or in the immediate vicinity of the station, many gaps may not afford the desired protection, although having an arcing voltage comparatively low for less severe impulses or those of longer duration. Also the characteristics of some gaps for positive impulses may be widely different from those for negative impulses. If therefore the gap is to furnish efficient protection, it must have characteristics corresponding to those of the insulation in parallel with it, both with respect to polarity and to time lag.

Impulse time lag characteristics for a typical bushing and several types of limiting gaps are shown in Fig. 4; to avoid confusion, curves for only one polarity are shown. In order to provide protection for the bushing having the characteristics shown in curve *A*, it may be assumed that the voltage limiting gap should flashover at not more than 90 per cent of *A* for all time lags indicated by curve *B*. The characteristic curve of the horn-gap shown as *C* has approximately the same shape as *A*, although it tends to depart somewhat for the shorter time lags. Reference to Fig. 3, however, shows that for that type of gap, the difference between positive and negative sparkover voltages is likely to be very large.

Referring again to Fig. 4 it may be noted that curve *D* for the ring-gap intersects curve *A* at approximately 585 kv. For transients having a crest below 585 kv., the ring-gap will sparkover first; for transients having crest values above 585 kv., however, the ring-gap does not afford protection, as the bushing will sparkover first. Therefore if the ring-gap is set as high as possible so as to minimize unnecessary interruption for transients of lower crest and longer duration, it will afford little or no protection for severe overvoltages when most needed. To provide protection against these severe overvoltages, the ring spacing and flashover voltage must be materially reduced, thereby causing unnecessary interruptions. For example, the minimum flashover voltage shown in Fig. 4 for the ring-gap is approximately 400 kv., as against 520 kv. for the bushing; a further reduction in the flashover voltage of the ring-gap is necessary in order to provide protection for high over-potentials.

Curve *E* of Fig. 4 shows the characteristics of a sphere-gap of negligible time lag having the same minimum flashover voltage as the gap of curve *B*.

s the time of voltage applications is decreased, owever, insulators and most equipment will with-cand much higher impulses. It is desirable there-ore that the impulse flashover of the limiting gap e higher for short time lags. If a limiting gap aving the rather uniform flashover characteristics f a sphere-gap as shown by curve *E* is used, un-ecessary flashovers will result owing to the spark-ver of the gap for the shorter time lags where the isulation can well withstand higher voltages. haracteristics of the sphere-gap may be modified aterially by changing the relative sizes of the pheres with respect to each other and with respect the gap spacing. As will be discussed later, is principle is made use of in the control type of ap to obtain the characteristic of curve *A′*, closely pproximating the ideal characteristic curve *B*.

ONTROL TYPE OF LIMITING GAP

A protecting gap will approach the ideal in so far s the following can be carried out:

It should be possible to control the time lag characteristics so at the gap will afford protection over the range of transients likely be imposed.

Negative and positive impulse breakdown characteristics of the otecting gap should correspond to that of the apparatus to be otected.

Flashover voltage of the gap should not be lowered seriously by in or surface contaminations.

Means should be provided for changing the relative negative d positive flashover voltages, where it is desired to work within ose limits or to protect apparatus or insulation, the properties of hich are not fully known.

It should be possible to change the time lag characteristics ithout materially affecting the minimum flashover voltage.

Where discharge of the gap will cause a serious service inter-ption, a fuse or other device should be used for clearing the normal-equency current following discharge.

The gap should not discharge under high frequency transients comparatively low magnitude caused by switching or arcing ounds.

A gap conforming to these requirements obviously should have improved characteristics over types in general use in the past; development of such a gap is described in the following paragraphs.

A protecting gap using spheres of proper size in relation to the gap spacing and of unequal diameters to provide for the difference in negative and positive characteristics of the equipment protected could be used to comply with requirements 1 and 2 just enumerated. However, the effect of water or other surface contaminations upon the flashover voltage of spheres would make it difficult to conform to requirement 3. Also the characteristics of the gap made in this way could not be changed easily and therefore would not meet the requirements 4 and 5.

As the spacing of a protecting sphere-gap is increased to lengths well beyond the diameter of the spheres, the flashover voltage for a positive impulse will tend to be lower than for a negative impulse. This can be offset by using a larger sphere for the live terminal and a smaller one for the ground terminal. Where the electrostatic fields of the two terminals of the gap are of equal intensity, the flashover will start from the positive terminal since a lower density is required to start discharge with a positively charged electrode. Therefore by controlling the flux density at the surface of a gap terminal, it is possible to vary the discharge voltage. This principle is made use of in the newly developed limiting gap, one form of which is shown in Fig. 4. The control shields in the vicinity of the gap terminals can be moved forward or backward to change the field density and regulate not only the time lag but the difference in negative and positive sparkover characteristics.

Test results (see Fig. 5) show that the relative negative and positive flashover voltages of the protecting gap may be controlled readily by changing the flux density of the positive arcing tip. Any screen or shield may be used to accomplish this. It is important, however, that the shield does not cause erratic performance by becoming one of the electrodes so that an arc will be struck between shields

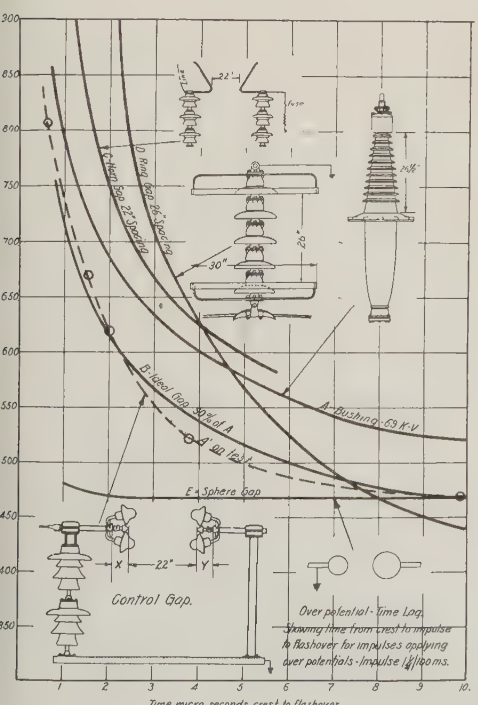


Fig. 4. (Left) Comparative impulse flashover characteristics for various gaps

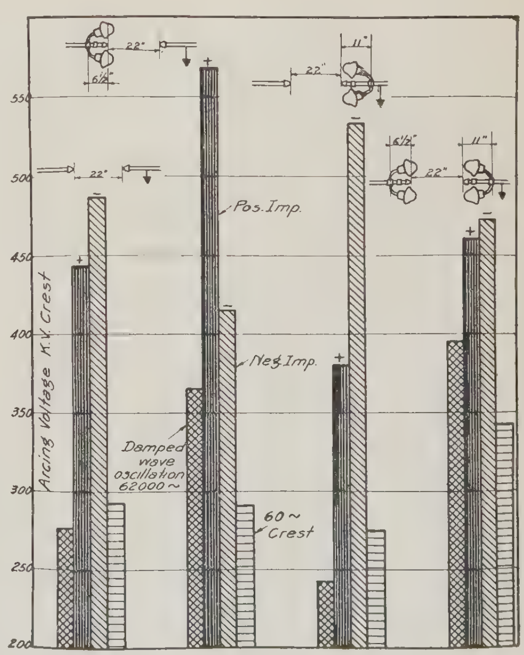


Fig. 5. (Right) Chart showing effect of insulated control screens upon arcing voltages of a 22-in. gap

or between one of the tips and a shield. By using the insulated type of shield this difficulty is obviated, even though the shields may be nearer together than the discharge points. This is particularly important in wet conditions or where the gap may be subjected to high frequency oscillations, for in these circumstances a gap having bare metal shields generally has a very low flashover voltage. Reference to Fig. 5 shows that control of the flux density of the discharge points by means of the insulated shields is quite effective in changing the relative arc overvoltage for negative and positive impulses. In addition it may be seen that the arcing voltage for a damped wave or oscillation compares favorably with that for an impulse, thereby reducing unnecessary discharges.

The change in relative negative and positive impulse sparkover voltages that may be effected by changing the flux density on the electrodes with insulated control shields is shown by Fig. 6 as well as Fig. 5. Reference to Fig. 6 shows that the arcing voltage for a negative impulse is approximately 75 per cent greater than for a positive impulse where the controlled screens have the same relation to the arcing tips, and where the control screens are well forward (C = 3 in.). Moving the control shield on the ground electrode back from the point of the gap reduces the screening on this electrode so that the discharge will start at a lower voltage for a given distance between terminals when the opposite terminal is negative. Moving the shield back on the ground side also reduces the flux on the live terminal so that the arcing voltage for a positive impulse will be raised. For example, by increasing C to 9 in. and reducing the screening effect of the control shield on the ground electrode, the positive and negative impulse va ues are brought in close agreement. Advancing the control screen on the live side toward the gap opening has the same general polarity effect as moving the control screen on the ground side away from the gap opening.

It is evident that the arcing voltage will be increased for a given gap spacing if the stress on the arcing tips is reduced by advancing the control shields; this makes it possible to reduce the gap spacing and time lag for a given flashover voltage. It necessarily follows that the characteristics of the gap may be changed materially, both as to time lag and the effect of polarity upon discharge voltage, by simply adjusting the control shields. As the projecting insulated control screen is affected but little by high frequency transients, it is possible to reduce the time lag without lowering the flashover voltage for waves of lower crest and long duration. In Fig. 7 the impulse flashover values for waves of different attenuation are given for a control type of gap and a ring equipped suspension string, respectively.

Control gaps of this type may be made in several different forms with plain shields or rings used in place of the insulated control screen. The latter has the advantage in that the gap does not have a low flashover voltage for oscillations and is affected but little by rain or conditions which may cause a gap with a bare metal shield to be erratic. Other forms of gaps embodying the principles outlined in some cases may work out to much better advantage.

Conclusions

Results of this study and development work indicate that:

1. An ideal voltage limiting gap for station use is one wherein both polarity and time lag characteristics are capable of adjustment over a sufficient range to allow protection of all apparatus in parallel with it for any transient wave form imposed upon the station.

2. A form of limiting gap has been developed, making use of adjustable electrostatic field controls for the gap electrodes. This allows the breakdown characteristics of the gap both as to time lag and arcing voltage for positive and negative impressed waves, to be varied over a wide range so as to conform to the characteristics of the station insulation.

3. The use of a control type of gap for limiting the severest transients only, and a lightning arrester for the remainder, undoubtedly will provide the best station protection and operation available at present.

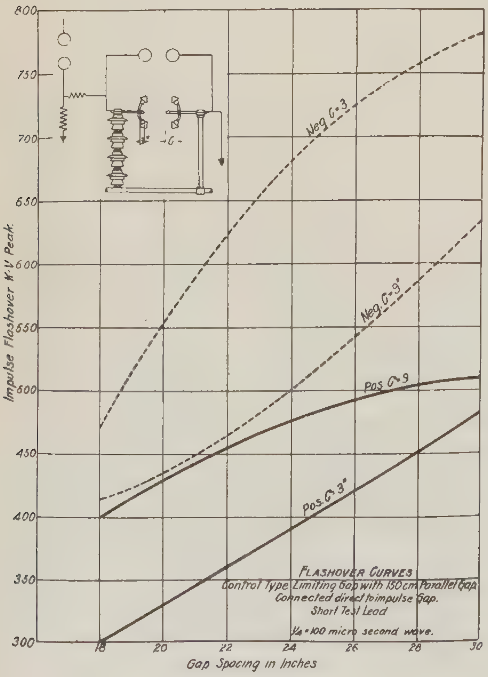


Fig. 6. (Left) Impulse flashover characteristics for a shielded gap with different adjustments

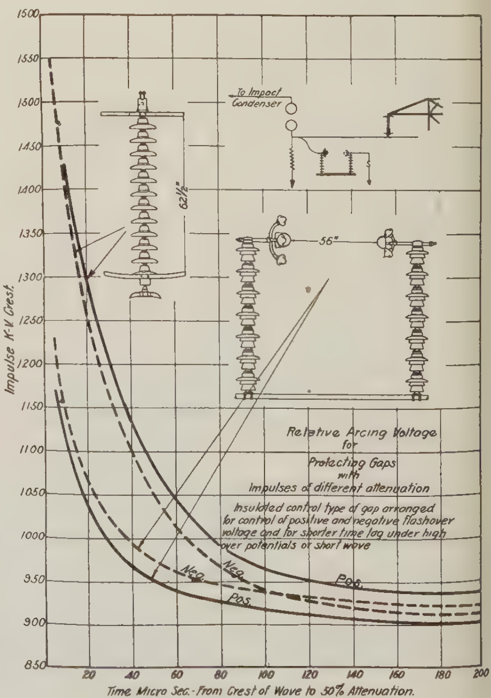


Fig. 7. (Right) Comparative arcing voltages of protecting gaps with impulses of different attenuation

Abstracts

Of Papers to Be Presented at the Pacific Coast Convention

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the A.I.E.E. Pacific Coast convention (Aug. 30–Sept. 2, 1932) are published herewith. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Members vitally interested and wishing to obtain a pamphlet copy of any paper available in that form may do so by writing to the A.I.E.E. Order Dept., 33 West 39th Street, New York, N. Y., stating title, author, and publication number of each paper desired.

The Power System of the British Columbia Power Corporation, Ltd.

By E. E. Carpenter[1]

THE SYSTEM LOAD of the British Columbia Power Corporation, Ltd., is concerned principally with lighting, domestic power, and small industrial power. With one exception no heavy contract load is carried. Owing to the seasonal and climatic influences the load factors are inherently low, the annual load factor ranging for several years between 45 and 48 per cent, with little immediate prospect of improvement. The peak load on this system, during the middle of December, is 100,800 kw.

The power supply for the system is derived principally from hydro sources although 3 steam plants are maintained for standby, emergency, and occasional peak service. The coastal region especially is favored in water power resources, although precipitation increases rapidly with altitudes any distance from the coast. Snow and ice at the higher elevations and dense forest growth over a large part of the area have a considerable effect on the power supply, while the glacial structure and topography lend their aid to providing favorable dam sites and storage basins for regulation, a necessary and expensive part of all the developments.

Details of the electric, hydraulic, and structural features of the principal generating plants of the system are described briefly in this paper, and the transmission and distribution system is summarized. **(For presentation only; not scheduled for publication by the Institute.)**

Segregation of Hydroelectric Power Costs

By W. S. McCrea, Jr.[3]

THE PRODUCTION COST of electric power is made up of the power or demand cost per kilowatt and the energy cost per kilowatt-hour. The relative amount of each of these items which make up the total cost of power at the power station determines the cost at any load factor. The above segregation of the annual production cost of power is essential in determining the power rates and the economic design of the production plants of an electric system.

The usual hydroelectric power station is designed to utilize as much of the potential stream flow energy as is possible economically with the type of load available. The annual costs of such a station having storage may be divided between those costs proportional to the generating capacity and those independent of the generating capacity. For use in the design of the station the energy available in the stream is fixed at some value, and is determined by the stream flow records. The energy cost of hydroelectric power from this type of station is the annual costs which are independent of the generating capacity divided by the useful stream flow energy. The demand cost is the annual costs which are proportional to the generating capacity divided by the power or kilowatts. This method of analysis is applicable to the majority of hydroelectric developments. The nature of a hydroelectric station is such that the factors that fix the cost of power are those which give an average cost over a period of years.

The discussion in the paper is divided into 3 sections. The first section is a brief outline of the method used in segregating system power costs and the development of the fundamental cost items. The second section has to do with the segregation of the power costs of hydroelectric stations into their component parts; the methods of developing the components for different classes of hydroelectric stations are outlined. In the last section the peculiarities of hydro power are given and the method of determining an average cost of power for a hydroelectric unit or system is outlined. **(A.I.E.E. paper No. 32-112)**

The Reading Company's Philadelphia Suburban Electrification

By G. I. Wright[4]

THE ELECTRIFICATION of the Reading suburban service in the vicinity of Philadelphia was first placed in operation July 26, 1931. The lines now under electrical operation include 65 route miles and 157 track miles, which will be increased by January 1, 1933, to 87 route miles and 203 track miles. These lines consist of 6 branches and cover all the suburban territory north of Philadelphia, between the Schuylkill and Delaware rivers.

Severe competition from automobiles, buses, a new subway, and the Pennsylvania Railroad's electrified lines had resulted in serious loss of traffic and revenue to the railroad. The Reading Company was faced with the alternative of impairing the existing steam operation to reduce costs, or providing a modern superior electrified service. The latter policy was decided upon and electric operation has now been in effect over a year. In spite of a 20 per cent speeding up of schedules and an increase in trains and train miles of approximately 100 per cent, the cost of operation is found to be substantially lower than for the service by steam in the same territory. The improved schedules combined with greater cleanliness and more attractive equipment have changed a steady loss in traffic into an appreciable increase. As a result, the railroad management recently authorized the electrification of the suburban service on its Norristown branch from Philadelphia to Norristown.

The present paper describes the electrification, giving details

1. British Columbia Electric Railway Company, Ltd., Vancouver, B. C.
3. Department of Public Works, State of Washington, Olympia.
4. Reading Company, Philadelphia, Pa.

of power supply, substations, catenary structures, signal bridges, transmission lines, and catenary system, and rail return system. Considerable information is given also on the multiple unit cars, together with motors and control. Interchangeability of apparatus was given special consideration during design, and many special features have been incorporated. **(A.I.E.E. paper No. 32-109)**

Electrical Operation on the Cascade Division of the Great Northern Railway

By J. B. Cox[5]

ELECTRIFICATION of the Great Northern Railway's main line between Skykomish and Wenatchee, 73 route miles, was carried out in conjunction with the building of a new tunnel 7.79 miles long, and the relocation of approximately 17 route miles of troublesome track and other minor improvements, aggregating an expenditure of approximately $25,500,000. Although all of these improvements were placed in operation at about the same time, making a direct comparison of operating expenses difficult, analyses which give a reliable comparison between the cost of steam and electric operation over this part of the system have been made.

Operating difficulties with this recent electrification, especially those occurring shortly after the equipment was placed in service early in 1929, are described in this paper. Some of these difficulties were due to the condensation of moisture caused by the sharp changes in air temperature at the upper end of the tunnel and toward which the draft of air flowed. Other changes in the locomotives and control were found desirable and are described.

Segregated operating costs with steam and electric operation are presented, and show that although the route miles with the present electrified section are only 8.8 per cent less than the route miles with the previous steam operated section, the total operating costs are reduced 57.3 per cent. Costs of the electrification also are presented. **(A.I.E.E. paper No. 32-110)**

Theory of the 3-Wire D-C. Generator With 2-Phase Static Balancer

By E. G. Cullwick[6]

AN ANALYSIS of the theory of the 3-wire d-c. generator using a 2-phase static balancer is presented in this paper with the particular object of explaining the very large unsymmetrical magnetizing current peaks which occur in the balancer windings. These peaks are evidence of unsymmetrical flux variation attaining high values of flux density; and as their value may be equal to, or greater than, the total unbalanced current in the neutral wire of the system, they have a pronounced effect upon the r.m.s. value of the currents, and therefore upon the heating, in the balancer phases. They also cause marked pulsations in the terminal voltages of the machine.

These magnetizing current peaks are out of all proportion to the actual magnetic unbalance of the 2 phases on the balancer core; and the mathematical development shows that they are cumulative phenomena, analogous in a general way to the cumulative growth of field current in a shunt generator, and depending for their initiation upon only a very small magnetic unbalance of the balancer phases, and upon a normal maximum flux density which lies above the perfectly straight portion of the magnetization curve for the balancer core.

An expression for the e.m.f. induced in the balancer phases by the alternating flux in the core is obtained. From this are analyzed the conditions governing the cumulative growth of the current peaks until a steady value is reached. It is found that any unbalance of the resistance of the balancer phases has a marked effect upon the phenomena, it being possible by the introduction of a suitable unbalance to cause the peaks to reverse. If the resistances of the 2 phases are kept equal, it is found that the value of the current peaks decreases with the increase in the resistance of the balancer windings.

These theoretical conclusions are verified by oscillograms, which, taken on an actual machine, clearly show the nature of the phenomena and their variation with the operating conditions of the machine. **(A.I.E.E. paper No. 32-111)**

Metering of Symmetrical Components

By R. G. Shuck[7]

CONTENTS of previous publications on metering of symmetrical components have been confined to the components of current and voltage in 3-phase 3-wire systems. This paper discusses the method of metering the positive and negative sequence power and energy in 3-phase 3-wire systems, and positive, negative, and zero sequence power and energy in 3-phase 4-wire systems. Networks are described which make it possible to meter these components simultaneously and separately. Tables are included showing the location and number of instrument transformers required for each network. Equations involving the design of the impedances of the metering systems are given.

In discussing the various metering systems, the possibility is suggested of metering large blocks of power at the alternator terminals with 1 wattmeter, a positive sequence network, 2 potential transformers, and 2 current transformers, used to replace 3 wattmeters, 3 current transformers, and 3 potential transformers. Also it is suggested that in relay and control equipment the components of power be utilized as well as the components of current and voltage. Where definiteness of action depends upon the amount of voltage available at the relay, positive and negative sequence components of power might be utilized in the relay. One relay using the balanced components of current and voltage will function regardless of which phase is short circuited.

A preliminary design of a complete set of network impedances necessary for simultaneous metering of positive and negative sequence power reveals that the equipment could be placed in a box having dimensions of less than 6x6x6 in. **(For presentation only; not scheduled for publication by the Institute.)**

Shaping of Magnetization Curves and the Zero Error Current Transformer

By A. C. Schwager[8] V. A. Treat[8]

NONE of the methods previously available to improve transformers is capable of producing an important requirement of the power industry; namely, the high accuracy, high voltage, low ratio, bushing type current transformer operated at a high secondary burden. However, in analogy with the molecular theories of magnetization, a method of shaping magnetization curves has been advanced for securing constant permeability. Tests prove this method to be very effective and to result in a permeability which remains constant within fractions of one per cent over a wide range of induction.

The method has been applied to the bushing or through type current transformer so desirable for the metering of high voltage transmission lines. For this type of transformer the exciting current of the core in the low flux density range of its normal operation has a

5. General Electric Company, Erie, Pa.
6. University of British Columbia, Vancouver, B. C.
7. University of Washington, Seattle.
8. Pacific Electric Mfg. Corporation, San Francisco, Calif.

nlinear characteristic. However, a much smaller core of varied oss-section, working at a higher flux density, can be made to have exciting current characteristic of almost exactly the inverse rvature and similar value to that of the current transformer core. If a reactor with such a core be connected in parallel with a current insformer secondary, the total exciting current of the combination n be brought to an almost exact linear relation with the secondary ltage or current for a considerable range of values. This linearity oduces a like relation as to primary and secondary currents. The s of secondary current due to the parallel reactor is restored by ducing the number of secondary turns to bring the transformer to a sired ratio, and the phase angle discrepancy is corrected by neulizing the major part of the exciting current by the reactive rrent of a parallel capacitor. A parallel resistor has a similar ect but the sensitivity of the transformer to burden variations is creased.

Current transformers with this auxiliary equipment (transrmer compensator) are adjusted for a fairly large burden, such 50 voltamperes and 0.50 power factor. A variable loading burden urden compensator) is placed in the secondary circuit so that a nsiderable range of external burden is possible without affecting e calibration curve of the transformer.

A 115-kv. bushing type transformer with a silicon-iron core when us equipped will give characteristic curves between 0.5 and 5 peres secondary current not exceeding variations of 0.001 in tio correction factor and 10 min. of phase angle. Greater accuracies an this are possible if required commercially.

High precision wound type current transformers also may be cured by this method at no substantial increase in cost or complition of construction. In the same manner zero error potential insformers and watt-hour meters, relays with prescribed charteristics and linear electric circuits including ferro-magnetic cores, e easily produced. **(A.I.E.E paper No. 32-116)**

actory Assemblies in Substation Design

By M. H. Hobbs[9]

DESIGNS and factory procedure for factory assemblies medium voltage substations which may be applied to either netrk or radial distribution systems are described in this paper. ese substations may be divided roughly into 2 principal classes, ose for serving large individual power consumers and those for neral distribution to a community of varied customers. In the ter class may be included also substations in very large industrial ints and steel mills having their own generating and transmission stems.

For so-called customer substations of the indoor type, the special quirements are usually limited space, low cost, safety, and simcity. Metalclad switchgear offers an ideal factory assembly for e high voltage side of such an installation, occupying as it does the nimum floor space both for installation and for operating aisles. om the low voltage side of the transformers a metal enclosed bus n is desirable, terminating in a metal enclosed structure with insformer and feeder air circuit breakers of either the draw-out oe or the fixed type. In addition to the metalclad construction, ick type and cubicles are available in factory assembled conuction. Customers' outdoor substations, comprising mainly the h voltage switchgear and transformers, also are available in this istruction.

Substations for general distribution differ from so-called cusner's substations largely in number of circuits, complexity of bus angement, and amount of meter and relay equipment used; ierwise similar apparatus may be used for both applications. ace may be at a premium on account of the larger amount of iipment to be accommodated, and in any case it is desirable of irse that ground space cost be kept as low as possible.

It is in the wholly outdoor form of substation that the greatest ving from the use of factory assemblies can be effected, since a ther saving comes from the elimination of the building. This applies whether the station is for a network or radial system. Cost analyses of factory assembled substation layouts show surprising over-all economy. **(For presentation only; not scheduled for publication by the Institute.)**

9. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

High Voltage Oil Circuit Breakers

By R. E. Rowley[10]

MECHANICAL maintenance of high voltage circuit breakers is of considerable importance to the successful operation of power systems. Experience obtained over a number of years has proved that in many ways existing equipment may be modernized and betterments provided by the operating engineer.

Some of the problems which have been encountered in maintaining and rebuilding high voltage oil circuit breakers in connection with a modern and fast growing system are indicated in this paper. It has been found that high voltage circuit breaker maintenance may be improved materially with the use of available apparatus such as the tuning fork and equipment for securing travel-time curves. Information obtained from such studies automatically will indicate whether improvements to the switchgear are necessary.

In the paper, details of the changes made to existing equipment are discussed; these include improvements in the solenoid, safety, and venting, and various other mechanical changes to give greater current carrying and interrupting capacities. The economy of rebuilding obsolete switches has been proved. In many cases, the rebuilding of switches has cost considerably less than new switches, and subsequent performance has been quite satisfactory, as all operations have compared favorably with those of newer equipment. **(For presentation only; not scheduled for publication by the Institute.)**

Corona Loss Measurements for the Design of Transmission Lines to Operate Between 220 Kv. and 330 Kv.

By J. S. Carroll[11] Bradley Cozzens[10]

DURING the summer and fall of 1931, measurements at the Harris J. Ryan Laboratory, Stanford University, Calif., extended the range of corona loss data for conductor sizes beyond those investigated during 1930. In these latter tests the 3 conductor specimens studied were a 1.125-in. hollow copper cable, a 1.49-in. hollow copper cable, and a 2.0-in. hollow aluminum cable. The losses were measured on a 3-phase line 700 ft. long. Voltages as high as 600 kv. between lines were used. The conclusions obtained in these tests are summarized as follows:

1. There are throughout variations in corona loss that result from causes at present unknown. These variations are of sufficient magnitude to be considered in the design of transmission lines and should be remembered when studying corona loss data.
2. Further evidence proves that the die, grease, and other foreign matter existing on cables as received from the manufacturers greatly increase the corona loss, and that this loss can be partially eliminated by washing the cable with a solvent soap solution and thoroughly rinsing in water.
3. The cleaning of the cable surface by scratch brushing only slightly lowers the corona loss below that which exists on a new cable properly washed.
4. The polishing of a cable surface by buffing temporarily decreases the loss on the cable below that which exists on a new cable properly washed.
5. Dragging a clean cable a distance of 1/2 mile increases the loss on the cable above that which is found on a washed cable, but the loss is less for this condition than for the new, unwashed cable as received from the factory.
6. The surface of clean washed cables that have been subsequently dragged ages rapidly, so that with a year of weathering the loss is practically the same as found on a new, washed, undamaged cable.

10. Department of Water & Power, City of Los Angeles, Calif.
11. Stanford University, Calif.

7. The surface produced by buffing ages rapidly, and as observed over one week's time showed a great variation in loss which was not regular but at times approached the loss value as found for the new, washed cable.

8. The variation in corona loss as found on new, washed cables shows that the voltage shift for the same power loss on cables of different sizes is practically proportional to $r \log S/r$, which is the factor in E_0 which is varied by dimensions. (E_0 is the disruptive voltage, r the radius of the conductor, and S the spacing.)

9. Insulator loss if not considered may introduce an appreciable error in corona loss measurements at high voltages. The loss can be partially eliminated by properly shielding the insulator strings.

10. A completely transposed line 1,050 ft. long showed the same corona loss as the same length of line untransposed. A horizontally spaced line showed a slightly higher loss than the same length of line with the equivalent triangular spacing.

In addition to the description and discussion of results of these tests, the paper includes a description of the modifications in the high voltage wattmeter for these measurements. **(A.I.E.E. paper No. 32-113)**

The Triple-Harmonic Circuit in 3-Phase Power Systems

By
T. H. Morgan[12]
C. A. Bairos[11]
G. S. Kimball[11]

THE IMPORTANCE of triple-harmonic voltages and currents in electrical power systems is generally recognized by engineers associated with the power and telephone industries. It is desirable to have some convenient method of representation and calculation of the triple-frequency effects in 3-phase power syst ms.

The path of the third-harmonic current is different from that of the fundamental current and for this reason the circuit can be considered as separate and distinct. The characteristics of the triple-frequency circuit as determined by laboratory experiment are given in this paper, and methods of measurement of the required quantities for accurate solution of the triple-frequency circuit are described.

The results of an experimental investigation of the equivalent triple-frequency circuit as proposed by H. S. Osborne in 1915 are set forth. A typical simple 3-phase power network has been set up and the measured currents compared with computed values. Oscillograms are presented of voltages and currents with typical transformer connections demonstrating the principles of operation of the circuit both for normal and abnormal excitation conditions. The effects of various types of connected loads are discussed with particular attention to the condition of triple-frequency resonance. It is shown that triple-frequency resonance occurs when the external capacitive reactance of the circuit is equal to the triple-frequency no-load impedance of the transformer. Resonance produces large triple-frequency currents and serious distortion of the line-to-neutral voltage of the system. **(For presentation only; not scheduled for publication by the Institute.)**

The Radio Plant of R.C.A. Communications, Inc.

By
H. H. Beverage[13]
C. W. Hansell[13]
H. O. Peterson[13]

THE Radio Corporation of America, through its subsidiary, R.C.A. Communications, Inc., operates a world-wide radio communication network between the United States and some 40 foreign countries. The major terminals of this world system are located at New York and San Francisco, with smaller centers at Honolulu, Manila, and Havana. The associated receiving and transmitting stations are located outside of these cities at various convenient distances.

A system has been worked out whereby all operations are concentrated in a central office at each of these terminals, thereby eliminating delays and errors inherent in the previous system of sending traffic over telegraph wires between the central office and the radio station. The development of short wave transmission also has greatly facilitated transoceanic radio service. Due to the great number of stations operating on both long and short waves, it is necessary to maintain means for monitoring the transmitters and for measuring the radiated frequencies with great accuracy. On the short waves, the frequency must be maintained within 0.05 per cent for old equipment and within 0.02 per cent for new equipment.

Starting with 6 circuits in 1920, these have expanded to a total of 54 circuits in 1932. During this period the number of messages also has increased greatly. Equipment necessary for this service of transmitting telegraph signals by modulation of radio frequency power is described in detail in this paper. Central office equipment, transmitting equipment for both long waves and short waves, receiving equipment, and frequency measurements are covered. **(A.I.E.E. paper No. 32-115)**

12. Worcester Polytechnic Institute, Worcester, Mass.
13. R.C.A. Communications, Inc., New York, N. Y.

Radiotelephone Experiments Over Short Distances

By
C. H. McLean[14]

RADIO in communication practise generally is associated with long distances over which physical plant is economically impossible. There are very few communities of appreciable size on the North American continent that are not linked up with the various telephone networks. Exceptions are to be found in British Columbia and Alaska where the territory intervening between the isolated settlements and populated areas is of such rugged nature as to render impossible from the standpoint of economy, the use of the usual telephone facilities.

Radio already successful over longer distance was adopted as the medium for providing telephone communication to the telephonically isolated centers lying within 600 miles north of Vancouver, B. C.

Radio experimental work on frequencies between 1,500 and 6,000 kc. has been in progress during the last 3 years employing equipment primarily designed for air transport communication. The radio transmitter has an unmodulated carrier rating of 400 watts, employs quartz crystal control of frequency and is capable of complete modulation. The receiver is of special design and includes the important feature of automatic gain control.

In the early experimental work a boat completely equipped with the necessary power plant and 400-watt equipment, cruised up the coast as far as southern Alaska, and tests were conducted between the boat and a land station located at Lulu Island near Vancouver. Considerable data relative to field strengths, fading and skip effect of various frequencies were collected for various points within a radius of 600 miles from the shore station. Further work included additional experimental installations at Campbell River, Ocean Falls, and Prince Rupert. Campbell River, the most northerly point connected by telephone lines, is the connecting point for the Ocean Falls (210 miles) and Prince Rupert (400 miles) radio links. Commercial operation over the last $1^1/_2$ years has proved the practicability of this form of communication, and it is believed that with the improved equipment now available, the expansion of this service upon a more permanent basis is justified. **(A.I.E.E. paper No. 32-114)**

14. British Columbia Telephone Company, Vancouver, B. C.

PLEASE GIVE PAPER NUMBER when requesting pamphlet copies of Institute papers; when the publication number is not given requests cannot be filled.

Middle Eastern District to Meet at Baltimore

THE next meeting of the Middle Eastern strict will be held at Baltimore, Md., ctober 10–14, 1932, with headquarters in e Lord Baltimore Hotel. A preview of e attractions which the Baltimore meeting ll offer is given by A. L. Penniman, Jr., the Baltimore Section as follows:

"The technical program will be of unusual terest, including a joint session with the mmittee on insulation of the National esearch Council at which papers will be esented covering the latest discoveries in electrics and the most recent developments cable research. There will be papers on lephone cable covering the recent advances the design and manufacture of pulp sulated cable, as well as on the use of cable r telephone distribution purposes, which ay be supplemented by inspecting the oint Breeze works of the Western Electric ompany, a modern telephone cable manu- cturing plant. The electric power session will be of particular interest as it will cover the economic aspects of water power, the design and construction of the Safe Harbor hydroelectric plant with particular reference to the hydraulic turbines which were especially designed for sustained efficiencies under variable head and at partial loads. There will be papers covering the 80-mile long, 230-kv. transmission line from Safe Harbor to Baltimore, the step-down station and the utilization of hydroelectric power in Baltimore with an inspection trip to the dam site where the Kaplan turbines, step-up station, transmission line river crossing and other interesting details may be inspected.

"Baltimore has much to offer visitors, not only in the development of industry but in the cultivation of art, literature, science, and engineering. In a little more than 2 centuries she has become one of the greatest manufacturing ports along our eastern seaboard but still retains the charm and culture which, with the aid of an ideal climate, developed from the inception of the province and produced such literary geniuses as Edgar Allen Poe, Sidney Lanier, Francis Scott Key, and James Ryder Randall of 'Maryland My Maryland' fame.

"The same courage and foresight which prompted Maryland to be the only one of the original 13 states to go through nearly the entire period of the Revolution as a separate and distinct sovereignty, then give to the federal government the territory now the District of Columbia and have its general assembly at Annapolis provide the necessary money for the completion of the federal buildings so that Congress might have a meeting place in the federal capital, also prompted the formation of the first gas-light company in 1816, and some 12 years later the starting of the first steam railroad in America and thereby laid the foundation of the fortune which was some half-century later to furnish the funds for the Johns Hopkins University, making possible incalculable contributions to science by such men as Rowland, Remsen, and Wood, and providing a fertile field for the rapid growth of the engineering school during its 20 years of existence under the able guidance of Whitehead and Kouwenhoven. Peale's Museum where the first gas lighting was installed and the Mt. Clare station from which the Baltimore and Ohio Railroad dispatched its first train and which on that historic day in May nearly 90 years ago received the first telegraphic communication in the world are both places of more than usual interest, as are the Flag House, where Mary Pickersgill made the American flag which waving over Fort McHenry inspired Key to write our national anthem, and the home of Charles Carroll, signer of the Declaration of Independence, which, splendidly preserved, is now a part of the Hopkins building group.

"A sightseeing trip and tea for the ladies will take them to Annapolis, the capital of the State for nearly 300 years, where General Washington surrendered his commission as commander-in-chief of the Continental Army, still retains the delightful atmosphere of colonial days. The old senate room has been preserved as it was when the continental congress met there while Annapolis was the nation's capital. King William's School founded in 1696, now St. John's College, is the third oldest institution of learning in the country, and was one of the first free schools in the colonies. Here is located the United States Naval Academy, in the crypt of whose chapel lies the remains of John Paul Jones, and here also is the flag which has given the Navy its watchword, 'Don't give up the ship.'

"The Baltimore Section urges you to come to the meeting in October with the assurance that you will find an unbounded hospitality."

One of the many points of interest which may be visited during the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932, is shown above. It is Mt. Vernon Place, looking north, and contains the first monument erected to the memory of George Washington. It was a gift from the French Republic

Last Call for the Pacific Coast Convention

INTEREST now is centered upon the next major event of the Institute's program; namely, the Pacific Coast convention to be held this year at Vancouver, B. C., August 30 to September 2, 1932. Details of this convention were published in ELECTRICAL ENGINEERING for July 1932, p. 518–9, and abstracts of all technical papers which at the time of publication of this issue were definitely scheduled, are given in this issue, p. 583–6.

Combined with the unusual entertainment features available in the region in such abundance and variety as to appeal to the "vacation" ideas of every man, woman, and child, the technical program and more formal features of the convention should attract a large registration.

Changes Made in Fees for Registration and Entertainment

Of no little interest to those planning to attend the convention are the changes which have been made in fees. There will be no registration fee for the convention. Entertainment tickets, however, which cover the dance after the president's reception on August 30, the boat trip on August 31, the dinner on the boat, the banquet on September 1, and, in the case of the women, the bridge tea on September 2, will be available at the following rates:

Members and men guests..........	$6.00 per strip
Women..........................	5.00 per strip
Students.........................	2.50 per strip

Tickets for separate items will be available for men, women, and students.

This new information regarding fees supersedes that given in ELECTRICAL ENGINEERING for July 1932, p. 518.

Exchange Rates Favor United States Currency

Consideration should be given by all persons from the United States attending the convention to the present rate of exchange between United States and Canadian currency. Persons from the United States may effect a net reduction of 15 per cent in the effective amount of expenditures on the Canadian side of the border by making an exchange from United States into Canadian currency at an established banking institution covering expenditures which will likely be made in Canada. United States money presented in Canada for payment of bills is accepted dollar for dollar without reference to the exchange rate which now favors United States credit.

A.I.E.E. Directors Meet During Cleveland Convention

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at the Hotel Cleveland, Cleveland, Ohio, on Wednesday, June 22, 1932, during the annual summer convention of the Institute.

Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Past-president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—H. V. Carpenter, Pullman, Wash.; H. P. Charlesworth, New York, N. Y.; L. B. Chubbuck, Hamilton, Ont.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; I. E. Moultrop, Boston, Mass.; G. C. Shaad, Lawrence, Kans. *Directors*—A. E. Bettis, Kansas City, Mo.; A. B. Cooper, Toronto, Ont.; B. D. Hull, Dallas, Tex.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. *National treasurer*—W. I. Slichter, New York, N. Y. *Acting national secretary*—H. H. Henline, New York, N. Y.

Present by invitation were: *Past-presidents*—Paul M. Lincoln, Ithaca, N. Y.; Charles F. Scott, New Haven, Conn. *Officers-elect*—K. A. Auty, Chicago, Ill.; G. A. Kositzky, Cleveland, Ohio; A. H. Lovell, Ann Arbor, Mich.; E. B. Meyer, Newark, N. J.; A. C. Stevens, Schenectady, N. Y.

The minutes of the directors' meeting of May 20, 1932, were approved.

A report of a meeting of the board of examiners held June 15, 1932, was presented and approved. Upon the recommendation of that board, the following actions were taken upon pending applications: 3 applicants were transferred to the grade of Fellow; 7 applicants were elected to the grade of Member and 30 were transferred to the grade of Member; 62 Associates were elected; 54 Students were enrolled.

Approval by the finance committee, for payment of monthly bills amounting to $42,808.20, was ratified.

For the purpose of stimulating more prompt payment of membership dues by the mailing of dues notices at shorter intervals, after May 1, 1933, Section 18 of the By-Laws was amended by replacing the second and third sentences with the following: "On August first, November first, and February first, notices shall be sent to those remaining in arrears, the February first notice to be accompanied by a copy of this section of the By-Laws."

Resolutions were adopted, expressing the directors' appreciation of the services of the Cleveland convention committee and its subcommittees.

Various recommendations adopted at the conference of officers, delegates, and members on June 20 and 21 were considered and referred to appropriate committees already in existence or to be appointed; and approval was given to a recommendation that the Districts be requested, when planning Districts meetings, to consider the formation in each case of a subcommittee of the general convention committee to coordinate all phases of student participation in the convention activities, and to schedule a student session which will not conflict with any of the technical sessions, inspection trips, or other events of the convention; or in lieu thereof, to consider scheduling one or more student papers in the programs of the main technical sessions.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

Generator room (left) and control room (right) in the Ruskin power plant of the British Columbia Power Corporation, Ltd., near Vancouver, B. C. Inspection of this plant will be made during the A.I.E.E. Pacific Coast convention, August 30–September 2, 1932. The generator, rated at 47,000 hp., is of the "umbrella" type

onvention Sports Trophy Information Completed

Supplementary information and a cor- ction are presented here to bring correctly to date the listing of winners of A.I.E.E. mmer convention sports trophies given on 521 of ELECTRICAL ENGINEERING for ly 1932. The name of L. F. Deming '11) of Philadelphia, Pa., permanent nner of the first Mershon golf trophy as misspelled in last month's report.

Concerning the Mershon tennis trophy it ould be recorded that the first trophy as offered for competition at the 1923 mmer convention held at Swampscott, ass., and was won in that year by J. P. ikonow (M'18) of New York, N. Y. In 25 the cup was won permanently by G. A. win (M'13) East Pittsburgh, Pa., who so had won the tennis tournament of 1924. In 1926 Past-President Ralph D. Mershon made available a second tennis trophy which was won in that year by L. B. Chubbuck (M'26) of Hamilton, Ontario, Canada.

These additional data together with a correction in the present address of Mr. A. J. Gowan make the following list of Mershon tennis trophy winners correct according to present Institute records:

First Trophy

1923—J. P. Nikonow, New York, N. Y.
1924—G. A. Sawin, East Pittsburgh, Pa.
1925—G. A. Sawin, East Pittsburgh, Pa.

Second Trophy

1926—L. B. Chubbuck, Hamilton, Ontario, Canada.
1927—G. A. Sawin (M'13) East Pittsburgh, Pa.
1928—P. H. Hatch (M'29) Stamford, Conn.
1929—A. J. Gowan (A'23) Rock Island, Ill.
1930—E. F. Lopez (M'18) Mexico City, Mex.
1931—J. K. Peck (A'27) New York, N. Y.
1932—R. A. Monroe (A'30) Pittsburgh, Pa.

merican Tentative Standard for Engineering Abbreviations Adopted

RINGING to a close a preliminary riod of several years of effort, the sectional mmittee on scientific and engineering mbols and abbreviations of the American andards Association recently made a final port to that Association embracing an merican Tentative Standard specifying d governing the use of abbreviations for ientific and engineering terms. This ntative standard is strictly an editorial ecification listing more than 200 abbre- iations considered as acceptable for use the preparation of technical manu- ripts, and setting forth 8 practical rules overning the use of such abbreviations in xt matter. In this initial list of abbrevia- ons the committee has included only the rms in most common use.

The tentative standard as it now stands, ith its list of abbreviations and its rules overning their use, has been accorded ficial approval by the A.I.E.E. and also by e American Association for the Advance- ent of Science, the American Society of ivil Engineers, the Society for the Pro- otion of Engineering Education, and he American Society of Mechanical ngineers. It is expected that these onsoring organizations will bring into onformity with the standard list the obreviations now used in their respective ublications, and from time to time will ontribute to the extension of the standard st by the addition of further mutually greeable abbreviations. In sanctioning ese abbreviations, each society authorized ose falling within the sphere of its pro- ssional activity, recognizing at the same me the other abbreviations as authorized the other organizations. Controversial obreviations were omitted from the list bject to subsequent settlement.

The subcommittee of the sectional com- ittee that carried on the research in obreviations for scientific and engineering rms includes G. F. Bateman, professor mechanical engineering, Cooper Union, New York, N. Y.; S. McK. Gray, Electrical Testing Laboratories, New York, N. Y.; W. T. Magruder, professor of mechanical engineering, The Ohio State University, Columbus, Ohio; Dr. W. N. P. Reed, assistant editor, Engineering and Mining Journal, McGraw-Hill Publishing Company, Inc., New York, N. Y.; H. E. Ruggles, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; working under the chairmanship of G. A. Stetson, editor, The American Society of Mechanical Engineers, New York, N. Y. Officers of the A.S.A. sectional committee on scientific and engineering symbols and abbreviations include J. F. Meyer, Bureau of Standards, Washington, D. C., chairman; S. A. Moss, General Electric Company, West Lynn, Mass., vice-chairman; P. S. Millar, Electrical Testing Laboratories, New York, N. Y., secretary; and S. McK. Gray, assistant secretary. The executive committee of the A.S.A. sectional committee includes J. F. Meyer as chairman and S. A. Moss as vice-chairman; also Dr. A. E. Kennelly, Harvard University, Cambridge, Mass., representing the American Association for the Advancement of Science; H. N. Davis, Stevens Institute of Technology, Hoboken, N. J., representing The American Society of Mechanical Engineers; and C. M. Spofford, Boston, Mass., representing the American Society of Civil Engineers.

Rules Given

To clarify a necessary distinction, the committee has ruled that:

A symbol is a letter or sign used in a formula as a substitute for any numerical value. A shortened expression for a name or a unit is an abbreviation and *not* a symbol. Concerning the use of abbreviations, the committee's recommended standard specifies that:

1. Abbreviations should be used sparingly in text and with regard to the context and to the training of the reader. Terms denoting units of measurement should be abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings, and texts for special purposes, the use of abbreviations should be governed only by the desirability of conserving space.
2. A sentence should not begin with a numeral followed by an abbreviation.
3. Short words such as ton, day, and mile should be spelled out.
4. Abbreviations should not be used where the meaning will not be clear. In case of doubt, spell out.
5. The use of conventional signs for abbreviations in text is not recommended; thus "per," not /; "lb." not #; "in.," not." Such signs may be used sparingly in tables and similar places for conserving space.
6. The committee indorses the movement which was begun by the international committee on weights and measures in omitting the period in abbreviations of metric units and further indorses the growing tendency toward the omission in abbreviations of other origin. In the interests of economy and the reduction of waste, the elimination of the period is recommended except where such an omission results in an English word. Exceptions to this practise will be found in a few mathematical and chemical terms, such as sin, tan, log, As, etc.
7. The letters of such abbreviations as A.I.E.E. should not be spaced (not A. I. E. E.).
8. The use in text of exponents for the abbreviations of square and cube and of the negative exponents for terms involving "per" is not recommended. The superior figures usually are not available on the keyboards of typesetting and linotype machines, and composition therefore is delayed; also there is the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and sometimes are difficult to avoid in text.

Principal changes that may be noted in the tentative standard list of abbreviations include the elimination of practically all periods from abbreviations, and shorter forms of some otherwise common abbreviations. As new material is set up for subsequent publication in ELECTRICAL ENGINEERING and other A.I.E.E. publications, such abbreviations as are used will be brought into conformity with the tentative standard list.

Permissible Abbreviations

In conformity with the A.S.A. tentative standard, the following partial list indicates the style of abbreviations recommended by the A.I.E.E. publication committee for use in Institute manuscripts and publications:

Acre-foot	acre-ft
Alternating-current (as adjective only)	a-c
Ampere	amp
Ampere-hour	amp-hr
Antilogarithm	antilog
Average	avg
Barrel	bbl
Baumé	Bé
British thermal unit	Btu
Calory	cal
Candlepower	cp
Centigram	cg
Centimeter	cm
Circular mils	cir mils
Circular-mil (adjective)	cir-mil
Cologarithm	colog
Cord	cd
Cosecant	csc
Cosine	cos
Cotangent	ctn
Coulomb	spell out
Counter electromotive force	counter emf
Cubic	cu
Cubic feet per second	cfs
Current density	spell out
Day	spell out
Decibel	db

Degree	deg
Degree (angular measure)	°
Degree Centigrade	deg C
Degree Fahrenheit	deg F
Diameter	diam
Direct-current (as adjective only)	d-c
Efficiency	eff
Electric	elec
Electromotive force	emf
Elevation	el
Engine	eng
Engineer	engr
Engineering	engg
Equation	eq
Farad	spell out
Foot	ft
Foot-candle	ft-c
Foot-pound	ft-lb
Gallon	gal
Gallons per minute	gpm
Gallons per second	gps
Grain	spell out
Gram	g
Gram-calory	g-cal
Henry	h
Horsepower	hp
Horsepower-hour	hp-hr
Hour	hr
Hyperbolic sine	sinh
Hyperbolic cosine	cosh
Hyperbolic tangent	tanh
Inch	in.
Joule	j
Kilocycle	kc
Kilogram	kg
Kilometer	km
Kilovolt	kv
Kilovolt-ampere	kva
Kilowatt	kw
Kilowatthour	kwhr
Lambert	L
Logarithm (common)	log
Logarithm (natural)	$\log_e$
Lumen	l
Lumen-hour	l-hr
Lumens per watt	lpw
Magnetomotive force	mmf
Mass	spell out
Megohm	spell out
Meter	m
Mho	spell out
Microampere	µa
Microfarad	µf
Micromicron	µµ
Micron	µ
Microwatt	µw
Mile	spell out
Miles per hour	mph
Milliampere	ma
Millifarad	mf
Milligram	mg
Millihenry	mh
Millilambert	mL
Milliliter	ml
Milimeter	mm
Millimicron	mµ
Million	spell out
Millivolt	mv
Minute	min
Minute (angular measure)	′
Month	spell out
Ohm	spell out
Ohm-centimeter	ohm-cm
Ounce	oz
Potential	spell out
Potential difference	spell out
Pound	lb
Pound-foot	lb-ft
Power factor	spell out
Radian	spell out
Reactive kilovolt-ampere	rkva
Reactive volt-ampere	rva
Revolutions per minute	rpm
Revolutions per second	rps
Root mean square	rms
Secant	sec
Second	sec
Second (angular measure)	″
Second-foot	(see cubic feet per second)
Sine	sin
Square foot	sq ft
Square root of mean square	rms
Tangent	tan
Ton	spell out
Ton-mile	spell out
Versed sine	vers
Volt	v
Volt-ampere	va
Volt-coulomb	spell out
Watthour	whr
Watts per candle	wpc
Week	spell out
Yard	yd
Year	yr

Summarized Review of Some Cleveland Convention Discussions

PRINCIPAL discussions of the Cleveland convention papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for June 1932, p. 405–13.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

THE ENGINEERING SUBJECTS IN THE COLLEGE PROGRAM

S. M. Dean (Detroit, Mich.) discussed this subject with the view that an increasingly large proportion of engineers eventually get into administrative positions. He agrees, however, than any electrical engineer must have a basic training in the fundamental concepts. Referring to Table I of the paper, he would include in the first prescribed group the fundamental courses as well as transmission and distribution; also electronics. He also suggested that a rather wide range of the more specialized subjects should be offered as electives to determine the "natural bent" of the student and to show him into what the various branches of the electrical engineering profession will lead him. The necessity for a successful administrative engineer to take a broad view of any situation, and his ability to set forth his ideas in a logical and convincing manner, were emphasized as important characteristics. He suggested, too, that the story of obstacles surmounted and of the men who contributed to this successful development of the various steps both from a strictly engineering angle as well as from the commercial point of view, would serve as a helpful background.

R. E. Hellmund (East Pittsburgh, Pa.) called attention to the lack of training in the mechanical features of machine design and engineering materials as shown in Table II of the paper. He stressed the point that all component parts of electrical machines and apparatus present mechanical problems and that the greater part of the work of electrical design engineers has to do with the mechanical phase. He believes that some of the time now devoted to heat, power, and hydraulics should be devoted to mechanical design and engineering materials; at least, he believes good courses on these subjects should be available to those wishing to go into design work.

A. E. Knowlton (New York, N. Y.) in his discussion of this subject urged generous support of Dean Lovell's plea that the electrotechnical content of the curricula be surveyed, but at the same time he warned against placing too much emphasis on statistical data. With regard to reversion to fundamentals and the elimination of specialization, two solutions were offered. One of these suggested a review of the content of fundamentals with a test of every item for its broad applicability over the whole range of energy magnitudes and diversified applications; those phenomena and principles having the widest range of adaptability to electrical activities would appear most entitled to be ranked as fundamentals. The other solution suggested that more stress be placed upon functional significance of electrical phenomena and the physical equipment devised to exploit them. The "horizontal" character of such a set-up would give the subject matter a bearing upon every branch of the art involving an exercise of those functions.

Another discussion by D. C. Jackson, Jr. (Lawrence, Kansas) brought out recent changes made in the electrical engineering curricula of both the University of Kansas and Kansas State College. The former now has a greater number of hours given over to fundamental course in electrical engineering, while the latter has increased the number of hours for electronics, making it a required rather than an elective course. These changes tend to substantiate the trend indicated by Professor Lovell in his paper.

Another view of this subject from the point of industry was presented by W. W. Lewis (Schenectady, N. Y.), who explained that graduates ultimately were absorbed through 3 main channels: large manufacturing companies; large public utilities; and small manufacturing companies, public utilities, and industrial plants. The first 2 groups maintain more or less extensive training courses and require broad training in fundamentals; but the latter group requires in addition specialized training to fit the graduate for immediate usefulness. Since very few students know until just before graduation in which group they will be employed, Mr. Lewis believes that it is obviously necessary to give all students the broad fundamental courses plus a number of specialized courses. He agrees that the subject of electronics is becoming increasingly important and that practically all of the courses listed in Tables I and II of the paper were desirable, with the exception of those on surveying and foreign languages.

Still another view from industry was contributed by L. F. Morehouse (New York, N. Y.). He questioned whether all of the required work should not be given in truly fundamental courses in which the broad fundamentals would be illustrated from every phase of electrical engineering. If this should be impractical it was suggested that required courses other than those designated as "fundamental" should have a more general content and be more widely illustrative of modern electrical engineering in its broadest application.

L. W. W. Morrow (New York, N. Y.) ably discussed the subject of technical

ıcation, calling attention to the need for gineering courses to keep abreast of the oidly changing art. An analysis of Table of the paper quickly raised a number of rtinent questions which indicated the riation in hours devoted to fundamental ırses, the lack of correlation between ıdamental course hours and additional quired or elective hours, the specialized ırses consistently taught, and the lack courses such as electrochemistry and ctronics. Upon analysis, such data owed very vividly an antiquated, superial, and cumbersome content for the chnical engineering courses. The next ep in this discussion, based upon Mr. orrow's broad experience and extensive ntacts, showed briefly but valuably what oblems confront practising engineers of day. In conclusion, the following recomendations were made relative to the techcal content of college courses: (1) Stick theoretical principles and apply them to current engineering applications; (2) minate the old, the standardized, and the solete principles and applications, and place them with new and live theories and plications; and (3) do not specialize in rms of arbitrary and artificial field divins of engineering, but require all students take the same fundamental course with few electives in specialized theory instead practise.

A. E. Silver (New York, N. Y.) also dissed this subject, and was of the opinion at natural ability justifying a 4-year urse should be devoted primarily to the ying of a foundation—learning the princies of accomplishment by effectively recting the forces at hand, acquiring the ait of making one's knowledge available d of value to others, and finding one's tural self—leaving specifications largely graduate work and one's later initiative d experience.

DUCATIONAL ASPECTS OF ENGINEERING AND MANAGEMENT

R. E. Hellmund (East Pittsburgh, Pa.) scussed this subject and emphasized parcularly the point that enthusiasm over e fact that engineering education had rned out personnel suitable for industrial anagement, should in no way lead to a minution of the technical engineering hase of the undergraduate program. It as pointed out that although only 25 per nt remain in technical work after the age 40, the majority soon after leaving llege are called upon to carry on technical gineering. He advocated that rather an change the undergraduate courses, anagerial training should be given in the rious postgraduate programs.

D. C. Jackson, Jr. (Lawrence, Kan.) also scussed this phase of the subject and it as his belief that engineering training ould continue to be valuable for manarial duties in industries based upon gineering. With students, there might a trend toward business courses, adinistration or management, but it apared doubtful whether such courses of udy could provide so satisfactory a traing as do engineering courses.

Another discusser, E. E. Johnson (Scheectady, N. Y.), related a number of inances where men who have demonstrated a high order of technical leadership gradually came into positions of technical management. He did not feel that inclusion of a fundamental technical background in engineering curricula would detract from the field of management.

The Engineer

HE IS THE master of the Laws of Nature. On a sound foundation of mathematics, science, and economics, he bends the materials and forces of Nature to his plan and rears the structure of civilization.

With vision, resourcefulness, and ingenuity, he labors to increase the comfort, wealth, and safety of his fellowmen.

He attacks his problems with the vision of the pioneer, the integrity of the scientist, the accuracy of the mathematician, the practicality of the business man, the resourcefulness of the inventor, and the courage of the conqueror.

He is the planner and builder. He builds his visions into enduring realities.

He is the pathfinder of civilization. He breaks down the barriers, bridges chasms, establishes communication, and straightens the way for commerce and human progress.

He is the protagonist of efficiency. He reduces the effort, eliminates waste, and increases production.

He is the creator of a Nation's wealth. He drains the swamps, reclaims the deserts, develops resources, and harnesses power. He builds the machinery of industry, the wheels of commerce, and the structure of business.

He is the great coordinator. He plans and directs the construction of projects representing the investment of millions of dollars and the labor of thousands of men.

He investigates with open mind, and gets the facts before he makes decisions. He plans with thoroughness and builds with fidelity.

To his rich heritage from the labors of past generations of engineers and scientists, he adds his contributions. He continues the work of forcing outward the challenging barriers that separate Man's efforts from the impossible.

By D. B. Steinman, President of the New York State Society of Professional Engineers, and Past-President of the American Association of Engineers. Reprinted from "The American Engineer" for February 1932.

RELIABILITY AND ECONOMY IN THE OPERATION OF LARGE ELECTRIC SYSTEMS

This subject was introduced very comprehensively by the presiding officer, F. H. Hollister (Chicago, Ill.), who told of the origin and objective of the symposium. He pointed out that each district had its own peculiar problems and that there were scarcely 2 alike. For example, Philadelphia with a major hydroelectric connection was contrasted to Chicago with no hydroelectric connection of any great importance. Each paper was believed to present a method of determining how each of the respective metropolitan systems with its particular characteristics is operated to secure maximum reliability and economy. In each instance, however, the goal is reached in a different manner by devious paths that rarely cross but it is believed that each system with its scheme of operation has ample backing and justification.

One of the interesting phases of a discussion by R. L. Thomas (Baltimore, Md.) related to the essentiality of accurately forecasting future loads under present economic conditions. It is his belief that under present conditions, any forecaster who predicts loads for even a year or 2 in advance, with an error of only 2 or 3 per cent, may consider himself fortunate.

J. R. Baker (Baltimore, Md.) in his discussion summarized indications in the papers which related to interconnections. Apparently they were not producing the widely connected geographical power scheme forecast by some of the early proponents. The true function of interconnection seemed to be of a supplementary nature, and the papers tended to show that the main reliance for power supply in any load area would continue to reside in power stations adjacent to the load.

Another discussion by C. M. Gilt (Brooklyn, N. Y.) considered 2 different methods of meeting the situation arising when it might become necessary to shut down a generating station completely. Costs for such systems at first might appear high, however, for the larger systems, the magnitude of such completely isolated stations is of the order of 500,000 kva., and makes use of the most economical size of units available.

Another part of a general discussion presented by J. R. Baker (Baltimore, Md.) referred to carrying out construction projects in advance of load requirements for reasons of reliability or economy in operation. He explained that such work had been confined chiefly to the replacement of obsolete and inadequate equipment. In general, for reasons of economy in operation the company was not committed to investments in advance of actual load requirements. The exception is in the case of such items as converting attended substations into the automatic type where definite labor savings can be predicted.

THE COORDINATION OF TRANSFORMER INSULATION WITH LINE INSULATION

R. N. Conwell (Newark, N. J.) cited objections to the fixing of transformer insulation at a definite arbitrary value and then relying upon the designer of a transmission line to coordinate with these values. Such a method, he explained, surely could not produce a well-balanced, satisfactory, economical, system design. The transmission designer is handicapped at the very

start by the necessity of meeting limits established without regard to service conditions or local factors, such as the character of the terrain, lightning exposure, frequency of storms, or the position of the line with regard to storm paths. He suggests that a suitable committee canvass thoroughly a large number of operating companies to determine preferences in future insulation levels, and he believes that the methods employed for coordination should be the basis of determining transformer insulation requirements.

F. J. Vogel (Sharon, Pa.) also discussed this subject; it is his belief that the coordination of transformer insulation with the gap was of great value not only to operating engineers but to the manufacturers in providing a yardstick to measure the surge strength of station apparatus. He felt that the gap would be used merely as the level in the case of very low voltages, and that for this purpose, the table in the paper might be extended.

J. B. Hodtum (Pittsburgh, Pa.) discussed justification for the development of the coordinated distribution transformer. He explained that such a transformer had been developed and had been on the market now for 4 years. Impulse tests confirmed by 4 years of service have demonstrated that these transformers would flash over the bushings before the transformer itself would fail. Over 5,000 such transformers have been in service without a single failure having been reported.

Another discussion of this subject by J. K. Hodnette (Sharon, Pa.) pointed out that if the transformers were designed in the usual way with the high-voltage winding divided into 2 or more parts, the initial voltage stresses across the coils would be reduced materially as compared with the coordinated design. From this material reduction in stress it would appear that the shields were not essential for building a transformer with coordinated insulation.

Characteristics of Surge Generators

C. L. Fortescue (East Pittsburgh, Pa.) discussed this subject and explained that the importance of the paper rested in the fact that the author had demonstrated that what might appear as extremely complicated circuits, could be represented with a close approximation by simple circuits. He believes that the author has shown the ease of predicting the actual wave under test conditions, thus permitting specifications for surge testing of apparatus without fear, provided surge measurements are properly carried out and calculations are made beforehand, to insure that the apparatus is receiving the proper test.

W. L. Lloyd, Jr. (Pittsfield, Mass.) believes this paper timely, well-written, and interesting, but he does not feel that the subject is particularly new. Reference was made to Mr. Peek's first lightning generator of 1913, and to the fact that the impulse voltages delivered by such a circuit have been subject to calculations.

Load Ratio Control Circuits

F. L. Snyder (Sharon, Pa.) in his discussion of this subject pointed out that whether an air-gap should or should not be used in the core of the reactor depended upon the characteristics of the circuit desired. In any event he felt that the tap changer, the transformer, and the reactor must be insulated for the voltages which may be impressed upon them under both normal or abnormal conditions. Conceivably, a tap changing operation might take place at the instant of line short circuit.

A. Boyajian (Pittsfield, Mass.) in discussing this subject felt that usually attempts to limit voltage rise by saturation result in just the opposite effect. Noncritical expectations based on r.m.s. characteristics come to grief, and the very feature (saturation) depended upon for protection, stings and pierces the insulation of the circuit by needle-shaped voltage peaks. In terms of elementary sine wave concepts associated with linear circuits and without recourse to advanced mathematics, he analyzed the meaning of saturation phenomena in an a-c. circuit as understood physically.

H. O. Stephens (Pittsfield, Mass.) discussed this subject. He referred to tests which showed that when preventive reactors with closed magnetic circuits were used, decided peaks in the voltage waves across the reactors were obtained, the arcing on the contacts was severe, and the contact life unsatisfactory. However, with air core reactors, or with iron core reactors having suitable air-gaps in the core so as to obtain a substantially straight-line volt-ampere characteristic throughout the working range, the bad peaks in the voltage across the reactor were eliminated and the life of the contacts greatly increased.

Influence of Brush Contact Drop on Commutation

R. E. Hellmund (East Pittsburgh, Pa.) in discussion of this subject gave an interesting hypothesis of contact phenomena which, although not as yet checked with results of experimental data, seemed valid. It is his belief that contact phenomena may eventually be explained in a rather simple manner by assuming certain mechanical conditions in the contact areas, nothing but ohmic resistance in the materials proper, and other already well-known phenomena.

L. A. Heath (Long Island City, N. Y.) cited the existence of ever-changing conditions of contact between brush and commutator. He referred to brush sparking when a cold rotary or generator is started and immediately carries full load. During this initial period the slope of the brush contact curve indicates too great an interpole field strength, but after sparking ceases, the contact curve is quite normal. Inspection of the brush faces during this initial period indicates that the brushes have changed their seating from that taken at the last shut-down.

Another discussion by W. E. Stine (Cleveland, Ohio) explained that the authors' theory of sliding contact and data submitted was in very close conformity with a theory which the discusser advanced several years ago to explain brush contact drop characteristics. The authors were asked a number of questions about the physical properties and mechanical conditions in connection with their work and points with which the discusser was not in agreement were cited.

Single-Phase Short-Circuit Torques of Synchronous Machines

L. A. Kilgore (East Pittsburgh, Pa.) in his discussion of this subject felt that the authors had presented a relatively simple solution to the difficult problem of calculating the pulsating torque of single-phase short circuits. He explained that the extended 2-reaction theory and the constant interlinkage theorem were applied to include the effect of direct and quadrature axis damping circuits.

Another discussion of this subject by B. L. Robertson (Berkeley, Calif.) made reference to the previous work on synchronous machines by Doherty, Penny, and others. The assumptions of, and conditions set forth in previous work were compared with those in the present paper, the discusser also pointing out the continued use of the theorem of constant linkages.

Wire Communication Aids to Air Transportation

H. T. Killingsworth (Cleveland, Ohio) in connection with this subject described the communication equipment of the Cleveland airport, which includes practically all of the features described in the paper. Five teletypewriter circuits radiate from Cleveland, paralleling the more important routes. The administration building which contains this equipment is connected to the long wave radio transmitting station, urgent messages being retransmitted to planes in flight by the use of the re-perforating equipment. Short wave radio equipment is used by the airport authorities in dispatching planes, both upon leaving and landing at the field.

Characteristics of Electromagnetic Radiation From Aircraft in Flight

The authors, J. C. Coe and T. C. Rives, were asked several questions concerning the possibility of obtaining effects similar to fading when flying rough, the factors upon which the distance free from fading depended, and comparisons between different types of antennas. It was explained that good flying conditions were encountered during these tests, and that variation in field strength would be due much more to the changes in orientation of the transmitting antenna with respect to the receiving antenna than to an actual change in altitude or distance. The attenuation undergone by earthbound rays was found to be independent of whether daylight or darkness obtained, and fading was encountered when the field strength became less than a certain value, this value depending upon frequency, time of day, etc. With regard to effects with the different types of antennas, it was explained that where distances are much greater than altitude, the trailing wire antenna would give a greater field strength; and as to the distance free from fading, this also would be favored by the trailing wire antenna rather than by the horizontal type.

Vertically Cut Sound Records

In connection with this subject Benjamin Olney (Rochester, N. Y.) discussed the

ctical limitations which prevent the lio broadcasting and receiving of high ality music as demonstrated by the hors. To obtain a high frequency range radio reception comparable to that which s demonstrated, the following steps uld be necessary aside from merely ending the frequency range of both the lio receiver and the broadcast system: frequency spacing of adjacent broadcast nnels must be doubled; (2) the effective wer must be increased to provide a greater nal noise ratio; (3) carbon button microones must be used with caution or ninated; and (4) transmitter overdulation must be avoided to a much ater extent than at present. Also space itations in the home would constitute principal limiting factor of low-freency reproduction.

EQUATE WIRING OF BUILDINGS

Philip Sporn (New York, N. Y.) in his cussion of this subject felt that the gineering profession as a whole, and the mbership of the Institute in particular, d not given sufficient attention to this bject. He hoped that the paper on this bject might serve as a prelude to others ich might describe advances and new velopments in this field. One of the portant reasons for the lack of progress this field was thought to be due to the neral belief that the National Electric de has a legal status, and that there is thing engineers can do except comply h this code. He pointed out that the le has no legal status of any kind except t which is given to it by municipal or er ordinances, and such legislation might l for installations in direct contradiction the code.

. M. Bryant (Minneapolis, Minn.) also cussed this subject and felt that the titute should cooperate with standardg bodies in the adoption of new codes of ing. An increase in the standards for ing so that conductors in new structures uld have sufficient capacity to permit reasing the illumination was recomnded. He believes that there is no type of building which better illustrates the changing tendencies than do the public school and buildings in institutions of higher education. An actual experience was cited and served to illustrate this point.

F. C. Caldwell (Columbus, Ohio) in discussing this subject referred to a simple application of differential calculus which showed that the greatest economy of copper for a 2-wire system will be attained when the permitted voltage drop is divided between a feeder and its branches, in proportion to the length of the feeder and the average length of the branches. Similar relations for 3-wire feeders could be worked out with any given relation of neutral to outside wire. This simple principle he stated has never been observed in treatises on wiring.

Another discussion on this subject by L. W. W. Morrow (New York, N. Y.) brought out that there are 3 aspects of wiring and lighting that should receive serious consideration by every man in the industry. These are the humanitarian, business, and technical aspects. With regard to business possibilities, he pointed out that a 30-story office building offers a load in the neighborhood of 36,000 kw. High-grade engineering and detailed attention is devoted to a 500-kw. industrial power load; although the lighting load is infinitely the larger, it receives but little attention. Also, each home market if adequately sold and engineered offers from 10 to 15 kw. of load. He felt that no more fruitful field for engineering than this existed in the industry, and that it should have serious attention.

A discussion by Morgan Brooks (Urbana, Ill.) referred to means for revising inadequate house wiring without recourse to complete replacement. He also brought out that the predicted installation of air-conditioning apparatus in homes makes adequate wiring a debatable question. As a remedy, he stated that often where coffee urns, toasters, and chafing dishes affect dining room illumination adversely, a single additional circuit can be installed economically, connected to the opposite side of the distribution system. Also judicious reconnection of circuits at the cut-out cabinet may save the expense of rewiring.

Taylor Reed (Reedsville, Pa.) recommended that there should be a revised code on adequate wiring of buildings to set limits of permissible momentary dip of voltage.

Another discussion of this subject by P. L. Alger (Schenectady, N. Y.) suggested that the wiring code committee prepare a supplement to the standard code to explain the minimum character of standard code provisions and give detailed figures on the possible savings to be made by the use of larger wire sizes and more numerous outlets.

CURRENT PROPAGATION IN ELECTRIC RAILWAY PROPULSION SYSTEMS

K. L. Maurer (New York, N. Y.) discussed this subject and pointed out that the peculiar feature of the type of circuit treated in this paper, as distinguished from the ordinary power circuit, is that one side is made up of a concentrated metallic conductor in parallel with a distributed conductor, the earth. The effect of the earth as a conductor, upon the electrical constants, cannot be neglected as ordinarily it might be in the case of the usual power circuit.

APPLICATION OF HIGH-SPEED RELAYS

E. H. Bancker (Schenectady, N. Y.) in his discussion of this subject felt that papers of this type which presented results actually attained in operating practise, were valuable as they point out to designing and application engineers factors which have been overlooked or neglected. In this way such papers offer the opportunity for a further improvement in protective relaying. These remarks were illustrated by several cases taken from the paper and analyzed by the discusser.

A NEW HIGH-SPEED REACTANCE RELAY

In connection with this subject Philip Sporn (New York, N. Y.) stressed the fact pointed out in the paper, that in spite of the high cost, because of the need of high-voltage instrument potential transformers, any system of distance relaying gives high speed protection for only about 80 per cent of a line section. He then referred to the pilot scheme for universal protection and the objections to using a separate set of pilot wires. As a solution to this difficulty, recourse was taken to the use of carrier current and tests which have been conducted. He explained that the scheme was a true power directional plan of protection, utilizing carrier current to perform strictly one function. Fast tripping relays in a section are locked out when the fault is external to that section; when the fault is internal, the fast relays will operate. Results of these tests showed that tripping under all conditions could be obtained in a maximum time of 3 cycles on a 60-cycle system.

RELAY OPERATION FROM BUSHING POTENTIAL DEVICES

A discussion of this subject by H. A. P. Langstaff (Pittsburgh, Pa.) which told of

dditional Locomotives for the Pennsylvania Railroad

VE of the electric locomotives for high speed passenger service on the Pennsylvania lroad are shown in the test yard of the Erie, Pa., works of the General Electric Comy. Each locomotive weighs 190 tons, and is rated as 3,750 hp.

the successful operation and functioning of a number of these bushing potential devices in service, was read by Mr. Langguth. When these devices were used for relays, Neon lamps or a high resistance voltmeter was recommended for checking the voltage which would assist materially in the finding of trouble that might occur within any of the circuits between the bushing and relays. Another point brought out was that no proof was actually obtained of the belief that atmospheric conditions have a limited effect upon the accuracy of the potential as obtained from these devices.

The Boric Acid Fuse

T. G. LeClair (Chicago, Ill.) discussed the features of this new fuse and he felt that the lack of an inflammable liquid filler was an excellent safety measure. He inquired about an opening in the inclosed type for the escape of gases, and the effect of failure when called upon to interrupt a current beyond its capacity.

Supervisory Control Systems

M. E. Reagan (E. Pittsburgh, Pa.) described the history of this development. It was interesting to note that the first comprehensive system of remote control and supervision of a large number of operations over a group of common line wires was put into operation at Cleveland in 1922. He also commented on how the fundamentals in these early installations stood the test of time, and are today relatively unchanged. The only addition to the excellent specification for performance appeared to be the anti-pumping control as presented by Mr. Oliver.

J. H. Oliver (Philadelphia, Pa.) discussed the operating experience obtained from the Reading Company's installation, emphasizing the last paragraph of the paper which reported that no trouble had been experienced from induction, no faulty indications or operations had been observed or performed, and no train delays had been caused by failure of the supervisory control equipment. The discusser also pointed out that more maintenance was required where several stations are operated in parallel on the same common conductors than when individual wires and individual systems are used for the control of each station.

Applications and Performance of Automatic Equipment

A. E. Anderson (Philadelphia, Pa.) in his discussion of this subject referred to the extensive use that has been made of the system of the American Gas and Electric Company. With regard to the economics of this equipment he pointed out that investments in automatic switchgear permit reduction in operating costs. In some cases it was possible to remove enough feeder copper to pay for a large share of automatic control. However, he brought out that with the increased reliability and speed over manual operation, together with other attendant developments, economics sometimes are of secondary consideration.

Another discussion by Robert Treat (Schenectady, N. Y.) demonstrated, by quotations from the paper, that a certain course of procedure results in a collateral and perhaps unexpected advantage which is more important or more valuable than the primary objective originally sought. As was found in the paper the automatic substation is often less expensive to operate than an equivalent attended one. But by its reliability, speed of action, and freedom from errors of judgment, the automatic station gives a brand of service which cannot be approached by even the best attended substations.

Report on Telemetering, Supervisory Control and Associated Communication Circuits

C. G. Wassal (Cleveland, Ohio) commended the committee for offering such a thorough presentation. He believes the report filled a need felt for a long time and it should result in a much closer coordination between the 3 groups, the manufacturer, the user, and the companies furnishing circuits for such purposes. It also was brought out that the communication circuits used for telemetering require 24-hour maintenance and in addition for open wire routes, alternate routes seemed advisable in case of a base channel failure.

Another discussion of the report was presented by P. MacGahan (Newark, N. J.) and called attention to the importance of the communication line problems. He also told of one of the earliest telemetering systems which was of the frequency class and installed on the Chicago, Milwaukee, and St. Paul Railroad. He explained that the impulses and the current balance systems have entirely superseded the frequency system in modern installations. He also referred to a report on remote metering by the committee on instruments and measurements in the A.I.E.E. Trans., v. 47, 1928, p. 1164, and he felt that the present report might be considered as an extension of the same subject.

Stress-Strain Studies of Conductors

J. A. Inglis (Toronto, Can.) believes the paper on this subject very interesting from the point of change in values of the modulus of elasticity of a cable. He felt it would be interesting to know if during these tests basketing or bird-caging was experienced at end conditions or connections, and if any records were taken of rotation. He also cited the importance of fatigue limits and suggested that it would be most advantageous if they were tabulated for the various metallic cables.

Vibration and Fatigue

In connection with this subject F. E. Andrews (Chicago, Ill.) explained that there are several 3-strand conductors now on the market, notably one of high strength material made by the Aluminum Company of America. Inquiry was made about experience with the use of sleeves on this conductor and if any special sleeve was necessary.

M. E. Noyes (Pittsburgh, Pa.) replied to the suggestion in the paper that different types of stranding of cables should be compared to determine their relative ability to dissipate energy by interstrand friction. He explained that this had been done successfully in the laboratory of his company on 120-ft. spans using a decrement method, by Mr. Kimball. The decrement of amplitude was measured from a trace taken after the source of forced vibration had been suddenly disconnected from the cable. This value is then substituted in the Kimball formula. Concerning consideration of new cross-section shapes and new types of stranding, Mr. Noyes called attention to the possibility of severe stress concentrations which might occur at span ends due to abrasions of the surfaces of wires. In his opinion any cross-section shapes of conductor which caused certain strands to stand out sharply would be liable to higher stress concentrations than the usual round cable.

Vibration of Overhead Transmission Lines

E. W. Dillard (Boston, Mass.) described field tests and experiences on the Fifteen-Mile Falls transmission line in connection with disruptive corona as a third cause of vibrating conductor. A test span, the exact duplicate of one of the spans on the line, was erected to confirm this hypothesis by experiment under controlled conditions. Rows of sprinklers installed above the span provided precipitation at will. Under simultaneous conditions of low wind velocity (under 4 miles per hour) and precipitation, vibrations were produced in all sizes of conductors from No. 14 AWG stranded copper antenna wire to 795,000-cm. A.C.S.R. with the exception of No. 4/0, 7-strand, hard drawn copper which seemed to have inherent mechanical characteristics which suppressed any tendency toward vibration. Conditions observed on the Fifteen-Mile Falls line and on the California-Oregon Power Company's system showed that vibration occurred on the 2 systems under identical conditions. This data led to several new principles in regard to conductor vibrations.

Another discussion by C. B. Basinger (Cambridge, Mass.) read by F. E. Deck, presented results of experiments made by H. L. Richardson (Cambridge, Mass.) and the author of the paper, at the Massachusetts Institute of Technology, to study the forces which act on a moving conductor surrounded by corona discharge. These studies showed that a force exists which is a function of the voltage on the conductor and of the velocity of the conductor relative to the air. In general, it is necessary for the conductor to be energized above the corona voltage and over the range studied a further increase in voltage increases the force.

Vibrations Due to Sleet

F. E. Andrews (Chicago, Ill.) also discussed this paper and he felt that the subject discussed was that which is generally known as "whipping" rather than "vibration." He also believes the conclusion in the paper that change in span length or change in tension of the cable does not effect the phenomena, is contrary to generally established formulas for traveling waves in a conductor. To him it seemed impractical to predict whipping by the application of the formulas developed.

Another discussion by L. L. Perry (Chicago, Ill.) gave evidence of extraordinary weather conditions in Illinois and Indiana on March 21, 1932. Conditions produced sufficient dancing of conductors to trip out 132-kv. circuits of both A.C.S.R. and copper. At Chicago the temperature range was only from 29 deg. fahr. minimum to 30 deg. fahr. maximum with a maximum wind of 35 miles per hour. Other conditions were cited and apparently all tripouts occurred at one point, as evidenced by burns on the conductors and ground wires. At this point only, the line had a diagonal run with about a 90-deg. angle with the wind.

A. E. Davison (Toronto, Can.) discussed this subject and cited the importance of keeping it prominently before engineers and executives. He referred to galloping as evidenced within a 100-mile radius of Niagara Falls with sleet loading and winds of 5 to 15 miles per hour. These conditions were shown by Mr. Davison from a film obtained through the kindness of the Niagara, Lockport and Ontario Power Co. In regard to this paper he explained that it correctly pointed out that in earlier references to "lift," "drag" studies were omitted. He felt also that there should be general agreement with the authors' conclusions.

1932 Lamme Medal Nominations Due Nov. 1

In fulfilment of By-Law requirements, a second posting is hereby given to the necessity of all nominations for the Lamme Medal for 1932 being submitted not later than November 1, 1932. (See ELECTRICAL ENGINEERING, June 1932, p. 417.)

Presentation of the 1931 Lamme Medal was made to GIUSEPPE FACCIOLI (F'12) consulting engineer (retired) General Electric Company, Pittsfield, Mass., at the opening session of the Institute's recent summer convention at Cleveland, Ohio.

Three thousand radio receiving sets now can operate independently on the same antenna without interfering with each other, according to an announcement by the Western Electric Company. The system is designed primarily for hotels, apartments, and other multiple dwellings, and is arranged to overcome the increasing problems which dwellers in such buildings face in obtaining good antenna facilities for their radios at reasonable cost. The principles employed in long distance telephone circuits are used in this equipment. The receiving system is protected against interferences which the ordinary lead-in wire commonly picks up from sources within a building, and the loss in receiving power usually caused by the great length of lead-in wire and its high capacity to ground is overcome. Each receiving set connected to the system is electrically isolated so that it cannot put any noises back into the system to disturb the operation of others on the line. The receiving set may be of any make the individual chooses. A vital part of the system is the "coaxial conductor" which serves as a lead-in wire. A lightning arrester, repeating coil, filters, an amplifier, and lines radiating throughout the building make it possible for each user to connect his set by plugging into a convenient socket. Smaller forms of this equipment are available also, and are suitable for even the individual home owner with only one radio receiving set.

Frank J. Sprague Receives Many Tributes

A feature of the meeting honoring FRANK J. SPRAGUE (A'87, F'12, HM'32 and past-president) and which was held in the Engineering Societies Building, New York, N. Y., on July 25, 1932, was the presentation to Doctor Sprague of a handsomely bound collection of nearly 500 letters of congratulation and appreciation. The existence of these letters was not known to Doctor Sprague until the conclusion of the meeting when they were presented to him as a complete surprise.

The program, as announced in ELECTRICAL ENGINEERING for July 1932, p. 526, included speeches of tribute delivered by Dr. J. H. Finley, associate editor of the New York *Times* and former commissioner of education for New York City, Frank Hedley, president of the Interborough Rapid Transit Company, New York, N. Y., Rear Admiral S. S. Robison, U.S. Navy, retired.

Classifying Doctor Sprague as having "the same relation to electric transportation that Thomas A. Edison bore to electric illumination," Mr. Hedley in his address stated further that "Doctor Sprague has not rested with the mere inventing or suggesting of new methods. He has recognized that the world often is too busy to pay attention to new and advanced ideas which are considered revolutionary, or to give them a trial unless forced to do so, and he has made it his business to do the necessary forcing. . . . He knows what it means to have the signals set against him and to be forced onto a side track and delayed. Nevertheless . . . his inventions have proved worth while and he had sufficient faith in them to fight for them, even when confronted with discouraging conditions and fierce competition." Mr. Hedley mentioned the modern multiple unit electric train control as exemplifying the importance of Doctor Sprague's contributions to transportation developments, and said " . . . The traveling public owes and always will owe a tremendous debt to him."

Doctor Sprague acknowledged the tribute in a short response, expressing his thankfulness at having been able to be of service to his fellow men in facilitating their convenient transportation. After mentioning briefly some features of his own work, Doctor Sprague ventured the opinion that although other modes of transportation are becoming more important, the railroads still remained the "vital foundation of the country." He stated further that "it would be folly to predict in the present low state of competitive traffic and world wide financial depression, that general electrification is advisable or even permissible in the near future. However, if some of the hundreds of millions of capital which the national government is ready to dole out for unproductive public works were diverted to legitimate and sane electric railway equipment a long step would be taken toward economic recovery."

Doctor Gano Dunn, past-president of the Institute (1911–12) presided over the meeting as chairman of the anniversary committee which included in its membership list a galaxy of names prominent in professional, educational, electrical, and transportation fields. Dr. C. T. Hutchinson (F'12) consulting engineer of New York City served the committee as its secretary, while Frank Hedley, W. B. Potter (M'96), G. A. Richardson (A'08), and F. H. Shepard (F'24) served the committee as its working unit.

Wood Poles for Overhead Electrical Lines.—The Bureau of Standards of the U.S. Department of Commerce has issued Handbook No. 16 on the subject of "Wood Poles for Overhead Electrical Lines." It is for sale by the superintendent of documents, Washington, D. C., price 10 cents, and contains considerable data on this subject.

Doctor Flinn Receives Honorary Degree

On June 17, 1932, Dr. A. D. Flinn, who since 1922 has been director of Engineering Foundation, New York, N. Y., received the honorary degree of doctor of engineering from Worcester Polytechnic Institute, Worcester, Mass. Doctor Flinn, a native of the state of Pennsylvania, received his bachelor of science degree from Worcester Polytechnic Institute in 1893, and in 1927 received the degree of doctor of applied science from the University of Louvain.

Doctor Flinn, a civil engineer, has been concerned for many years with the activities of the entire engineering profession. Between 1895 and 1918, he was successively engineer with the Metropolitan Water Works, Boston, Mass., managing editor of *Engineering Record*, New York, N. Y., engineer on the Croton Aqueduct Commission, and deputy engineer and deputy chief engineer of the Board of Water Supply, New York, N. Y. (Catskill aqueduct). Since 1918 his office has been in the Engineering Societies Building where he has served since that date as secretary of the organization carrying successively the names, United Engineering Societies, Engineering Foundation, Inc., and United Engineering Trustees, Inc. From 1918 to 1921 he also was secretary of the Engineering Council. In addition to being director of Engineering Foundation since 1922, he has been secretary of that organization since 1918.

Doctor Flinn was a member of the National Research Council, 1918–1923, and chairman of its division of engineering 1920–1923. His technical affiliations include fellow of the American Association for the Advancement of Science, member and past director of the American Society of Civil Engineers, and member of the American Institute of Mining and Metallurgical Engineers, the American Iron and Steel Institute, and the American Society for Testing

Materials. He is honorary foreign member of the section of engineering societies of the Masaryk Academy, Czechoslovakia, Knight, Order of the White Lion, Czechoslovakia, and member of the Japan Society, Sigma Xi, Sigma Alpha Epsilon, the Engineers' Club, and the Century Association. Doctor Flinn was a joint author of the "Waterworks Handbook" published in 1916, and has been a contributor of numerous papers and articles on engineering topics.

Airship Institute Dedicated at Akron

The new Daniel Guggenheim Airship Institute at Akron, Ohio, was dedicated with impressive ceremonies on Sunday, June 26, 1932. The program included a communication from Harry F. Guggenheim, president of the Daniel Guggenheim Foundation for the Promotion of Aeronautics, and addresses by Dr. G. F. Zook, president of the University of Akron, and Dr. R. A. Millikan (M'22), chairman of the executive council of the California Institute of Technology, Pasadena. This Airship Institute at Akron has been made possible by a gift of $250,000 from the Guggenheim foundation to both the University of Akron and the California Institute of Technology for the study of lighter-than-air problems. The gift was supplemented by $100,000 from the city of Akron. After expenditures for building and equipment, funds remained for the conduct of research work during the next 5 years. A most important part of the equipment is a vertical wind tunnel, the largest in existence.

On the second day, June 27, a conference was held on progress and problems of research in lighter-than-air craft, with Dr. R. A. Millikan as chairman. Among the large number of speakers, all outstanding experts in aeronautical engineering and research, who took part in this conference are: Karl Arnstein, vice-president in charge of engineering, The Goodyear-Zeppelin Corporation; Garland Fulton, chief of lighter-than-air section, Bureau of Aeronautics, U.S. Navy Department; J. C. Hunsaker, vice-president and general manager, The International Zepplin Corporation; Theodor von Karman, director, The Daniel Guggenheim Airship Institute; W. E. Kepner, Air Corps, Wright Field; and C. B. Fritsche, general manager, Detroit Aircraft Development Corporation. The subjects discussed during this conference fall under the following headings:

1. Aerodynamics of airships.
2. Thermodynamics.
3. Meteorology.
4. Structural analysis.
5. Instruments.
6. Engines and power plants.
7. Materials.
8. Aerostatics.

Dr. C. E. Skinner (A'99, F'12, and junior past-president) served as the representative of the A.I.E.E. at the exercises on June 26 and 27. The following statement, taken from a letter of Doctor Skinner's reporting the exercises, summarizes the purpose of The Daniel Guggenheim Airship Institute and its relation to electrical engineering:

"This Institute is to be devoted entirely to the study of problems incident to the building and operation of lighter-than-air craft. Many of the problems which have been selected for study and experiment have a very direct relation to the problems in electrical engineering, and I have no doubt that on this account our Institute would do well to keep in touch from time to time with the work of The Daniel Guggenheim Airship Institute.

"The problems of most direct interest are probably those having to do with the movement of air through passages, the surface friction of air over bodies, the transfer of heat, etc. These all have direct relation to the problem of ventilation in electrical machinery. There are many other problems in connection with the physical characteristics of construction and materials, the study of stresses and strains in structures, etc., which have a less direct bearing but which are similar to problems encountered in the construction of electrical machinery and apparatus."

Doctor Burgess, Leading Physicist, Dies

George Kimball Burgess, director of the U.S. Bureau of Standards, Washington, D. C., died suddenly on July 2, 1932, of cerebral hemorrhage. Doctor Burgess was born at Newton, Mass., in 1874, receiving his bachelor of science degree from Massachusetts Institute of Technology in 1896, and the degree of doctor of science from the University of Paris in 1901; honorary degrees of doctor of engineering were conferred upon him by Case School of Applied Science, 1923, and Lehigh University, 1925.

GEORGE K. BURGESS

Between 1896 and 1903, Doctor Burgess taught physics at M. I. T., the University of Michigan, and the University of California. Since 1903 he has been connected with the Bureau of Standards, being successively assistant physicist, associate physicist, physicist and chief of the division of metallurgy, and since 1923, director, in which position he succeeded the first director, the late S. W. Stratton. High temperature measurements and metallurgy were the fields in which most of his scientific work as a physicist was concentrated; among his noteworthy achievements are the application of optical pyrometry to metal in furnace and rolling processes. His work on standards for light measurement, details of rail structure, causes of rail failure, and many other phases of metallurgy was outstanding and has continued to be of considerable assistance to workers in these fields. A large expansion of the bureau's activities occurred while he was director, and he was responsible for the development of the research associate system under which industries carry on research work at the bureau through their own employees advised and assisted by the staff experts of the bureau.

Doctor Burgess contributed freely of his time to the work of scientific and technical societies. Among the societies of which he was a member are the National Academy of Sciences, American Society for Testing Materials (past-president), National Research Council (chairman), American Society for Steel Treating (past-president), American Engineering Standards Association (director), the American Institute of Mining and Metallurgical Engineers, the American Physical Society, and the Optical Society of America. He was an honorary member of the American Foundrymen's Association, and the Japanese Society of Mechanical Engineers. He had also been chairman of the federal specification board and the national screw thread commission, and a member of the national advisory committee for aeronautics. In 1927 he was U.S. delegate to the seventh international conference on weights and measures in Paris, in 1929 was U.S. delegate to the world engineering congress in Tokyo, and had been president of the Annual Conference on weights and measures. He was a member of Sigma Xi fraternity and the Cosmos Club. In addition to many scientific articles and papers, he was the author of "Recherches sur la constante de Gravitation," 1901; "Experimental Physics—Freshman course," 1902; and "The Measurement of High Temperatures" (with H. Le Chatelier) 1912.

Insulation Committee to Meet in Baltimore

The electrical insulation committee of the National Research Council has announced its plans to hold its regular annual meeting at The Johns Hopkins University in Baltimore, Md., at the same time that the A.I.E.E. Middle Eastern District is meeting there. This will facilitate a joint meeting of these organizations tentatively scheduled for Monday afternoon, October 10, at which time 4 papers in the field of high voltage underground cable insulation and performance will be presented.

Two other technical sessions of the electrical insulation Committee will be held. In those sessions the results of recent research in the fields of dielectrics and insulation will be presented in the form of informal reports of progress made by manufacturers, scientific societies, and governmental and university laboratories. These sessions are scheduled to be held at the School of Engineering, Johns Hopkins University, under the general supervision of Dr. J. B. Whitehead, who is chairman of the committee.

etters to the Editor

TRIBUTIONS to these columns are invited Institute members and subscribers. They d be concise and may deal with technical s, articles published in previous issues, or subjects of some general interest and pro- nal importance. ELECTRICAL ENGINEERING ndeavor to publish as many letters as possible, f necessity reserves the right to publish them in or in part, or to reject them entirely. State- s in these letters are expressly understood to de by the writers; publication here in no wise itutes endorsement or recognition by the ican Institute of Electrical Engineers.

oor and ngineering Progress

he Editor:

r. William Green's contribution to the posim on "Has Man Benefited by neering Progress" (see "Labor and neering Progress," ELECTRICAL ENGI- RING, May 1932, p. 318–9) is, to my l, the most encouraging contribution received.

s depth of view and understanding is derful evidence that one need not ssarily have had a typical engineering ation to have the engineer's method of oaching a difficult subject.

ost of all, it is encouraging to me, use it contains the first invitation that neers have received from one not in profession, to expand their field of ilness to mankind.

e, as engineers, have had exceptional ntages and some of us have had the age to say that our methods should xtended into other fields, including of human relations, but no such estion has come to us from bankers, ers, or politicians.

hat such an invitation should first come a self-made man, like Mr. Green, who resident of the world's greatest labor nization, is indeed encouraging indica- that engineering methods are be- ing to be appreciated outside the pro- on.

sincerely hope that the Engineering ndation and American Engineering ncil will both find ways and means ooperate with Mr. Green.

Very truly yours,
W. S. MOODY (F'12)
(Consulting Electrical Engineer,
155 Dawes Ave.,
Pittsfield, Mass.)

he Editor:

e article by Mr. William Green on oor and Engineering Progress" in ELEC- AL ENGINEERING for May 1932, p. 9, is a fine contribution to the economic very of the country.

ere is no doubt but that the present nine age with its mass production, effi- y systems and the infinite number of saving devices, requires a compensator e form of a shorter work week.

hen the salesmen find that their former mers cannot buy their goods due to being out of employment, business rs, also machinery and plants become cially insecure.

al prosperity demands that the maxi- number be employed. At no additional expense to the employer the present man-hours of work should be apportioned so that the weekly amount of work will be done by more workers. The work week should be shortened, keeping the same hourly rate of pay, until all unemployment is absorbed. We are being forced to this conclusion. The longer the delay the harder it will be to recover.

When all who want to work are employed, business will soon pick up, with leaps and bounds, due to available money to spend, which will create a healthy demand. Salesmen will be happy and salaries will rise as the general prosperity increases.

Production will be balanced by work hours.

Very truly yours,
H. S. HALL (M'25) (616 East 8th St., Brooklyn, N. Y.)

To the Editor:

After reading that most commendable article, "Labor and Engineering Progress" by William Green, which appeared in ELECTRICAL ENGINEERING for May 1932, p. 318–9, the writer was moved to wonder if this article and articles of a similar nature in this series, as well as the President's message, have made any deep impression on engineers at large. It seems that most engineers are all too prone to lose themselves in the maze of technical work and lose sight of the less tangible problems mentioned in above paper, the equitable distribution of goods, profits, and labor. These are certainly complex problems which are worthy of an engineer. Since the engineer is largely responsible for the creation of the giant, machine age, which is threatening to annihilate us in its unguided and staggering course, surely he is not going to sit down and leave to bungling politicians the task of providing a system of control for his robot. In other words, the engineers' work is only partly done and he must devote some of his time to the solution of these important problems.

It does not seem enough to utter a mild appeal to members at large to take a more active interest in such matters or to leave the burden of their solution to a few engineers who are actively engaged in politics, for it seems that a few men with ideas cannot put them into effect without strong support. If anything of value is to be arrived at, it requires concerted effort from the engineering body as a whole. Of course, every engineer should acquaint himself more with the matters of government, finance, and politics than he has done in the past, and should have no hesitancy in coming forward with criticisms, ideas, etc., at any time. Now it seems that this concerted effort of the engineers should be directed by the various engineering societies, that is, why should not each engineering society have a special committee of notable engineers to investigate and present reports and recommendations on these problems from time to time in the same manner they would investigate a special phase of technical work. Thus the engineers as a body would be in a position to offer solutions to pressing problems and to exert the necessary pressure for their adoption in industry and government. If the President had such a body behind him, he could effect many of the necessary reforms which he, no doubt, has in mind and is at present almost powerless to carry out due to strong group opposition. Therefore, it is time the engineer cast aside his habitual reserve and deference to the politician and join the fray in a concerted effort to find a scientific solution to the problems which urgently need solving.

It is not assumed that all our difficulties would be solved by the magic touch of the engineer, or we would arrive at the millennium at once, but it certainly seems that more active and concerted effort by the engineers in the solution of these difficulties would be preferable to experiments of bolshevism or socialism which may come unless the machine age is put under sensible control. No doubt the suggestions outlined above will provoke some criticism and suggestions. If so, this letter has accomplished its purpose.

Very truly Yours,
J. R. HANGO (A'31)
(Arvida, P. Que., Canada)

Reactive Power Units and Terms

To the Editor:

I desire to call attention to the apparent disregard of the "unit of reactive power" and the term "reactive power."

The adoption of this unit—the "var"—and the provisional adoption of the term "reactive power" by the International Electrotechnical Commission in session at Oslo, July 1930, were reported in ELECTRICAL ENGINEERING for February 1931, p. 142.

It would be unreasonable to expect all authors to adopt these conventions immediately, but I do believe that our committee reports should utilize any and all definitely adopted nomenclature, thus hastening its general usage.

It is quite possible that I have overlooked some article using the "var" but to the best of my knowledge the unit has not been used until in A. E. Kennelly's article, "Recent Developments in Magnetic Units," in ELECTRICAL ENGINEERING for May 1932, p. 343–5. The adoption of a unit of reactive power comparable with the unit (watt) of active power is a valuable advance, as the "reactive voltampere" has been a cumbersome unit.

In respect to the term "reactive power," though only provisionally adopted, the desirability of its use in conjunction with "active power" is, I believe, obvious. Reactive voltamperes as a term has no more excuse for its use than has its complementary term active voltamperes. By refraining from the use of either of these (reactive voltamperes and active voltamperes) the unit of apparent power—the voltampere—is available without the slightest need of the qualifying prefix "apparent." Thus 2 distinct phases of the power expression are provided:

1. Apparent Power = Active Power $\pm j$ Reactive Power
2. Voltamperes = Watts $\pm j$ Vars

In a recent committee report, "Proposed Definitions of Terms Used in Power System Studies" (No. 31M2) and some other articles, the convention $P \pm jQ$ has been used to represent the right hand side of the above equations. This is leading us directly into an ambiguous situation. P is commonly accepted as the symbol for power. And power has been commonly used interchangeably with active power, though it is becoming more apparent that this is a

serious error—as attested by the increasing interest in the reactive power component in energy sales considerations, and the difficulty of explaining this new factor to the layman.

It is certain that a considerable amount of educational effort will have to be expended to clarify this situation. Why not make as much gain as is possible since some revising is necessary. Two lines of procedure are suggested to me. They are:

1. Place power on the left side of eq. 1, that is, drop the "apparent" from power as we did above from voltamperes, making the unit of power the voltampere, of active power the watt, and of reactive power the var. This is the preferable though more radical change.

2. Continue the use of power in lieu of "active power" and adopt some other term for reactive power (quadro is suggested to me by the symbol Q). "Apparent power" is still a source of trouble and should be replaced by some other term.

According to A.I.E.E. Standard, "Letter Symbols for Electrical Quantities" (17g1), A and S are available for assignment as symbols. A is readily adaptable as the symbol for active power in suggestion 1 above.

Power = Active Power ± j Reactive Power
$$P = A \pm jQ$$

For active power the symbol A could nicely represent apparent power, although the letters VA are quite suitable:

Apparent Power = Power ± j Quadro
$$VA = A = P \pm jQ$$

I further wish to indicate that I favor the convention watts ± j vars to represent active power and leading reactive power as tentatively adopted by the committee.

Very truly yours,
FRED B. IRWIN (A'31)
(1430 Hawthorne Avenue, Portland, Oregon)

The Way Out of the Depression

To the Editor:

In response to the invitation to discuss the article "Progress Is the Way Out of the Depression" by Mr. A. W. Berresford in ELECTRICAL ENGINEERING for December 1931, I am sending the following: The first paragraph contains a statement about the depression that seems extraordinary for an engineer to make. "There is little of value at the moment in attempting to isolate and correct the major causes." Can we imagine this attitude applied to any engineering work? Can we imagine an engineer saying that there is little value in trying to isolate the causes after a bridge or a dam failure? Can we imagine an engineer saying, after a bridge failure, that the causes will gradually emerge as time provides a perspective? To be sure, study of the causes will not rebuild the bridge, but it may prevent a second failure.

If the solution is left to time, we are likely to see the economic and social errors that produced the dark ages repeated; in fact, much of the "quantity of understanding" which Mr. Berresford says has increased so much within the last 18 months seems to be a reversion to the errors refuted by the economists of the last 200 years.

"The mere fact that stabilization of employment is economically dependent upon controlled production, and consumption dependent upon stabilized employment, will unite all elements in a common demand for that solution." This statement forms the basis of many of the popular fallacies, chiefly because it is so plausible. But nature has decreed otherwise. As long as the farmer does not know whether he will get 10 bushels or 40 bushels when he plants an acre of ground, stabilized production is impossible. To attempt stabilization probably will cause greater instability.

Consider a state with industrial activities stabilized to the greatest possible extent. Each company has its quota of production with the men for whom it is responsible. Now nature produces an unexpected crop, 25 per cent greater than the farmers had planned. This leaves a surplus for next year, so that there should be a reduction of 25 per cent in the number of men on the farms for the next year. With every industry stabilized where are they to go? Instead there is an unemployed surplus of men on the farms with resulting distress and reduced purchasing power. This in turn affects the industries, reducing the possibility of employment, and consuming reserves if any have been accumulated. The attempt to maintain stability is an attempt to thwart economic laws; but the laws will win and worse troubles develop.

What we need is flexibility, not stability. We need a mobile labor force as well as flexibility of management. We need industries that can increase or decrease their working forces according to conditions, and we need an economic inducement to make them increase and decrease at the right time for the public good.

One simple inducement which can be applied without much change in the present economic structure consists of an expansion of the currency with falling commodity prices. When a surplus crop is produced, the currency should be expanded to hold a large part of this crop over for a future year. The expansion of currency will result in stimulating industrial demand so as to provide jobs for the farm help released by the excess crop. This is only one step, and it will not prevent unemployment or business depressions altogether, but it is a step in the right direction. A more important step is the reorganization of education; but that is too complicated a problem to discuss here. The important thing to keep in mind is that whatever action is taken, it should be to provide greater flexibility, to make it easier for men to change from one kind of work to another as conditions change. It should tend to break the ties that now too strongly bind men to the jobs where they long have worked.

Very truly yours,
A. W. FORBES (A'12) (Forbes and Myers, 172 Union St., Worcester, Mass.)

Paralleling Rotor and Stator

To the Editor:

In the March issue of the ELECTRICAL ENGINEERING appeared an article based upon an interesting paper by Conrad and Warner: "Induction motors with parallel rotor and stator." The synopsis of the complete paper points out that "this method of operation was new to the authors and to several eminent induction motor designers and as no reference has been found to others employing this principle . . . " etc. In connection with this statement, it may be of some interest to both authors and readers, to learn that the same subject has been covered in the Archiv fuer Elektrotechnik, v. 20, 1928, p 162, by Tolwinsky and Hochberg (Leningrad) in a paper (German): "Asynchronous operation of a three phase induction machine with stator and rotor connected to the same supply system."

The information (theoretical develo[pments] and experimental results) contain[ed] in the German paper is supplemented by [a] few valuable remarks concerning the pra[c]tical application of the principle involve[d]. After pointing out the disadvantage of t[he] low power factor at small loads, the Russia[n] authors emphasize the fact that the supe[r]position of a low-frequency current wave o[n] the power supply system currents will b[e] rather undesirable in so far as it will caus[e] flickering of lights connected to the sam[e] system. As a consequence it must b[e] feared that public utilities may prohib[it] application of said principle to moto[rs] connected to their power systems.

Very truly yours,
A. VAN NIEKERK (A'24)
(Designing Engr., Westing[house] Elec. & Mfg. Co., E. Pittsburgh, Pa.)

Mechanical Analogs of Electric Circuits

To the Editor:

The use of electrical analogs for mechani[cal] systems is based on definite analogie[s] of form between the mathematical equa[tions] which describe the behavior of eac[h] type of system. The design of a mechanica[l] phonograph (see "Methods of High Qualit[y] Recording and Reproducing of Speech an[d] Music, Etc.," J. P. Maxfield and H. C. Har[rison], *Bell Sys. Tech. Jl.*, v. 5, July 1926, p[.] 493) by electrical engineers some years ag[o] apparently gave an impetus to the use o[f] electrical analogs, although there has bee[n] comparatively little written on the subject. Skilling (see "Electric Analogs for Difficul[t] Problems," H. H. Skilling, ELECTRICAL EN[GINEERING], Nov. 1931, p. 862–5) has show[n] an application in a particular problem an[d] has outlined some of the important ad[vantages] of the use of equivalent electri[c] circuits.

The opposite process—use of mechanica[l] analogs for electric circuits—does not appea[r] to offer comparable advantages, particularl[y] as far as circuit theory and ease in deter[mining] experimentally the action of a syste[m] are concerned. In certain cases, however[,] mechanical concepts may be of assistance t[o] the electrical engineer. Several instance[s] are cited below.

Consider Newton's Law of Motion

$$F = \frac{dG}{dt}$$

where

F is the vector resultant of the forces acting on a[ll] the particles of a mechanical system

G is the vector sum of the momenta of all the pa[r]ticles.

If $F = 0$, then G is constant, which is th[e] well-known law of the conservation o[f] linear momentum.

The electrical analog of momentum (ma[ss] times velocity) is magnetic flux linkages (in[ductance] times current) and the equivalen[t] of the mechanical law is the electrical prin[ciple] that in a circuit or group of circuits i[n] which the resistance is small the flux lin[kages] remain constant (approximately) wh[en] the forces (e.m.f.'s) are withdrawn, as o[n] short circuit. (A capacitor gives rise to [a] force obeying Nooke's law in the electri[c-]mechanical analogy.) This principle [in] electric circuits has not been very wide[ly] used, so that a comparatively recent writ[er] (see "Short-Circuit Currents of Synchrono[us] Machines," R. F. Franklin, A.I.E.E. TRAN[S.], v. 44, 1925, p. 863–72) has felt it necessa[ry] to refer to a proof. That this analog of o[...]

:hose laws of mechanics which are con-
:red most fundamental is an electrical
iciple which has not been utilized by
ineers for so very many years lends sup-
t to the thought that mechanical laws
prominent than the conservation of
mentum may yet point out electrical
iciples of value in particular cases. The
gral developed by Carson and applied
him to the analysis of electric circuits
which the usual circuit laws (Kirchoff's
s) were not readily applicable has been
wn to have been used in equivalent me-
nical form before electric circuits were
wn.

Experience indicates that most students, luding those with some advanced train-, consider work and kinetic and potential rgies from the mechanical viewpoint, ticularly when they understand the elec--mechanical analogy. Thus work is e times distance, hence e.m.f. times rge, while kinetic energy is $^1/_2\ mv^2$ for a ticle, hence $^1/_2\ Li^2$ for a simple series uit, etc. The magnetic energy is not ays called kinetic energy, and the elec- field energy is not always called poten- energy, but it is of advantage to under-nd the analogy when for example the ion of a system involving both electric l mechanical circuits such as a telephone eiver is analyzed. (See "Theory of ephone Receivers," R. L. Wegel, A.I.E.E. RNAL, v. 40, 1921, p. 791–802. In this er the total kinetic energy of an electro-chanical system is set up and used in the grangian equations to analyze the sys-.) The use of many advanced dynami- principles (Lagrange's equations for mple), which are usually equally appli-le to electric circuits, requires the setting of expressions for the total kinetic and ential energies of the complete mechani- electrical, or electromechanical system. should be noted that the possibility of lication of these mechanical principles to e electric or electromechanical systems y be ascribed to the (formal) equiva-e of mechanical for electric systems her than vice versa.

nother conceivable case in which known chanical principles might be used is in nection with the equilibrium and sta-ty of an electromechanical system. The chanical principles now available should ice if need arises.

None of the above examples is very im-tant in itself. They have been offered ply to illustrate some of the advantages oe derived from the consideration of me-nical "circuits" as analogs of electric uits.

Very truly yours,
J. G. Brainerd (A'32) (Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.)

nior Engineers Plan Industrial Projects

the Editor:

he article "Junior Engineers Plan In-trial Projects" appearing in the July 2 issue of Electrical Engineering, p. is of considerable interest.

he procedure of the program described he article should be of interest to all nbers of the Institute Sections and nches. There can be no doubt that the anization of the junior members within r respective local branches will produce active continued interest among the ng members.

he forming of these hypothetical com-ies and the solution of the problems involved should give the junior engineer an invaluable practical experience, as well as a chance to show his initiative and ability when confronted with a definite responsibility.

Local firms and public utility organizations, also elder members of these concerns or Institute Sections, should cooperate with the junior groups in offering their criticisms, suggestions, and experience.

This, then, is a very definite step in demonstrating to the junior engineer or graduate in what line of specialization he is more recommended, as well as forming a fraternal bond between the junior member and the profession.

Very truly yours,
Harry A. Etkin (A'26)
(520 McClellan St., Philadelphia, Pa.)

Consumption, Production, Distribution

To the Editor:

In the progress report of American Engineering Council ("The Relation of Consumption, Production, Distribution," Electrical Engineering, June 1932, p. 373–9), it seems to be assumed that savings have been too great. As a check on this theory I tried to secure the best data that I could find on the actual savings of the country, and have plotted the values in a curve, Fig. 1. This curve shows an estimate of the actual total volume of property, which is the actual measure of savings, as estimated by the U.S. Census and by the National Industrial Conference Board. I have corrected the figures for increase in population and for the change in the value of the dollar, giving the result in figures that are supposed to represent actual property, not dollars. It is plotted to a logarithmic scale so that the same slope of the curve indicates the same rate of increase at any point on the curve.

Of course the figures are not accurate. No one can tell just how much property you or I have, and no one can tell exactly the relative value of the dollar in times 50 years apart. But the figures are honest efforts to give comparable data, and the big differences shown leave us quite sure that they do represent a real change.

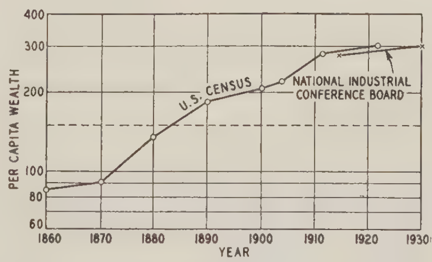


Fig. 1. Per capita wealth of the United States expressed in index numbers. The scale is so selected that the slope of the line is the same at all positions if the per cent increase is the same

First we see that the decade of the civil war was a time of slow increase in wealth, as would be expected. There was another slow rate of increase at the time of the 1893 depression, whether cause or effect is hard to tell. But the slowest rate of all has been the last few years. Unfortunately both recent figures include the period of the war, but the fact that both the latest figures of the census and the National Industrial Conference Board agree so closely would lead us to think that increase of wealth has not yet made its normal start, after the war.

Modern machines are expensive, and modern industry cannot operate without a greatly increased volume of capital. It is impossible to tell how much of the wealth shown by the curve is capital, but this failure of wealth to make a normal increase leads to the natural conclusion that capital has also failed to make its increase, and without this increase industry cannot function properly. This is merely one fact that supports the conclusion that one major cause of the present troubles is a shortage of capital. Therefore any method toward relieving the depression must be watched to see that it does not cause any further drain upon savings and capital. If it does it will probably cause more harm than good.

Very truly yours,
A. W. Forbes (A'12)
(Forbes & Meyers, Worcester, Mass.)

(**Editor's Note:** This letter is the second by Mr. Forbes discussing the economic problems covered in American Engineering Council's progress report.)

Standards

Wires and Cables

Three standards for wires and cables were approved by the American Standards Association on May 21, 1932, as follows: "American Standard Definitions and General Standards for Wires and Cables" (C8a-1932); "American Tentative Standard Specifications for Weatherproof (Weather Resisting) Wires and Cables" (C8k1-1932); "American Tentative Standard Specifications for Heat Resisting Wires and Cables" (C8k2-1932).

The first of these, the definitions and general standards for wires and cables, includes definitions and standards of a general character applicable to wires and cables for power purposes, and comprises a rearrangement of A.I.E.E. standard No. 30 of October, 1928, which has been brought up to date with certain additions and deletions. It contains definitions for the various types of wires and cables, conductivity standards, designation standards, high voltage test standards, insulation resistance standards, capacitance or electrostatic capacity standards, and maximum temperature limits.

The specifications for weatherproof wires and cables (C8k1-1932) cover weatherproof wiring and cables and the materials used for coverings and saturating compounds as applied to metallic conductors. The specifications are divided into the following headings: covering; saturating compound, which includes the tests therefore; stranded cables, including sizes of conductors and the stranding therefore; standard weights; a table of weights and weatherproof wires and cables; samples for tests; tests on copper conductors; and explanatory notes.

The specifications for heat resisting wires and cables (C8k2-1932) cover the usual type of heat resisting covering commonly known as "slow burning" as applied to metallic conductors for use in hot, dry locations where the other types of insulation would not long endure, or where the presence of large masses of inflammable materials would be objectionable. As explained in the standard itself, "There are many types of heat resisting materials used for insulating electrical conductors, but no attempt is made in this specification to cover anything but the so-called 'slow burning' insulation. The various types of asbestos coverings and enamels are for special purposes and are generally put out under trade names."

Printed copies of these documents on wires and cables will be available in the near future.

Radio

Two new national standards for radio were approved by the American Standards Association on May 21, 1932, as follows: "Standard Vacuum Tube Base and Socket Dimensions" and "Manufacturing Standards Applying to Broadcast Receivers." These standards were developed by the sectional committee on radio working under the procedure of the American Standards Association, with the Institute of Radio Engineers and the A.I.E.E., the directing sponsors.

The first of the standards applies to certain details in the manufacture of broadcast receivers, which it is desirable to have uniform in the sets of all manufacturers; the second standard specifies dimensions for many of the principal types of bases and sockets of vacuum tubes used in both receiving and transmitting. The types of base covered in the standard are 4-pin bases of the large and small type; large 4-pin base without bayonet pin; large 5-pin base without bayonet pin; 4-pin transmitting tube base; large transmitting tube base: 4-pin sockets for receiving tubes; and 5-pin sockets for receiving tubes. The standard also specifies dimensions for terminal caps for both receiving and transmitting tubes and for connections between the tube elements and the pins.

The manufacturing standards applying to broadcast receivers establish a national standard for the frequency range of receivers from 550 kc. (545.1 m.) to 1,500 kc. (199.9 m.). The rating and design of socket-power devices and electric radio receivers are to be standardized for operation on from 105 to 125 volts. A standard test for quality of soldering of cord tips or terminals to radio cords also is provided. This test is a straight pull of 5 lb. applied to the cord tip or terminal. Other details for which standard dimensions are established are cord tips, binding posts, cable terminals, radio plugs and jacks, and pilot lamps. There also are standard definitions for the various parts of radio receivers. Information with regard to these standards may be obtained from the American Standards Association, 29 West 39th Street, New York, N. Y.

Code for Protection Against Lightning

The sectional committee for the code for protection against lightning, working under the procedure of the American Standards Association and the sponsorship of the A.I.E.E. and the National Bureau of Standards, has completed a revision of parts I and II of the code. The original code was printed as "Miscellaneous Publication No. 92 of the Bureau of Standards," and information with regard to the proposed revision may be obtained from the chairman of the sectional committee, Dr. M. G. Lloyd, Bureau of Standards, Washington, D. C.

Proposal Made for Emergency Lighting Code

The National Electrical Manufacturers Association has asked that consideration be given by the American Standards Association to the preparation of a code for emergency lighting. It states that for some time their codes and standards committee has been considering codes for lighting systems designed to insure adequate illumination for emergency use in such places as theaters, hospitals, schools, and other buildings. While there are many state and municipal codes governing such installations, there is little uniformity among them. At various times attempts have been made to incorporate rules governing these installations in the National Electrical Code and the National Electrical Safety Code. This proposal of N.E.M.A. now will go before the standards council of the American Standards Association.

Test Code for Transformers

The standards committee of the Institute has asked that attention be called again to the "Test Code for Transformers." This code, which is the first of a proposed series of test codes covering electrical machinery and apparatus, has been out in its preliminary form for criticism and suggestion since October 1931.

In order to determine the performance characteristics of electrical machines, methods of testing have been developed and are in common usage. It is the purpose of these test codes to provide in convenient form the more generally applicable and accepted methods of conducting and reporting tests of a commercial nature and applying to the fulfilment of performance guarantees. In general the reception of this code has been favorable. Suggestions of a helpful nature have been received and the committee hopes this notice will result in a final clearing up of any debatable points so that publication in final form may be undertaken shortly. Copies of the preliminary report on the code may be obtained without charge. Address all communications to A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y.

Personal

Joseph Slepian (A'17, F'27) consulting research engineer of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., upon June 13, 1932 received the John Scott Medal for his "discoveries in the field of the deionization of gases and fundamental and outstanding inventions involving these discoveries." This award carries with it besides the medal and certificate, a premium of $1,000 cash; it was presented to Doctor Slepian with due ceremonies at the Union League Club of Philadelphia. The award was established by John Scott, a chemist of Edinburgh, Scotland, who in 1816 bequeathed to the city of Philadelphia a fund of $4,000, the income from which was "to be distributed to ingenious men and women who make useful inventions. . . ." After the fund had grown to $100,000 in 1917, court orders enlarged its use and specified that the premiums should be awarded "for inventions that will be useful to mankind in the development of chemical, medical, and any other science, or development of industry in any form; the test being that it may add to the comfort, welfare, and happiness of mankind." Doctor Slepian is a Bostonian by birth; his degrees of A.B., A.M., and Ph.D. were all won at Harvard University, the last one being conferred upon him in 1913, with mathematics his majoring subject. The winter of 1913 was given over to a semester at Göttingen University, Germany, and the following spring, to a semester at Sorbonne University, Paris, France. For a year he was instructor in mathematics at Cornell University, and in 1916 he joined the Westinghouse Company's East Pittsburgh force as an apprentice. His promotion to research engineer took place the following year, and in this and in a consulting capacity he has rendered exceptional service to his company. His conspicuous work upon circuit interrupting devices and his use of the unique principle of deionization in the destruction of powerful and violent electric arcs have been important contributions to the field of electric power transmission and distribution.

JOSEPH SLEPIAN

[. L. Wills (A'20) assistant to the vice-
sident, and also general manager, of the
rgia Power Company, Atlanta, Ga.,
ticipated in the A.I.E.E. 1931 national
e for best paper in engineering practise
rded the symposium on coordination of
ver and telephone plant, composed of 4
ts of which the paper, "Status of Joint
velopment and Research on Noise
quency Induction," by Messrs. Wills and
ckwell was a part. Born in Burlington,
, he started an apprenticeship in the
chinist's trade at the early age of 14.
next undertaking was in the capacity
transitman for the Wisconsin Central
lroad. By 1885 he was assistant to the
rating engineer of the Schuyler Arc
ht Plant, and from that time on over an
ended period of years he continued to
d positions of increasing responsibility.
1902 he joined the Georgia Railway and
ctric Company, at Atlanta, to assume
rge of the meter and maintenance repair
ps, a service which he continued for 6
rs. During the latter portion of his stay
h this company, he was directing these 2
artments and also in charge of the con-
ct department. His service as general
nager of the Savannah Lighting Com-
ny was from 1908 until 1912, when he
ned his present company, the Georgia
wer Company, as district manager, with
ces at Macon, Ga. Upon consolidation
his company with the Georgia Railway
l Power Company, he was transferred to
anta, Ga., as special detail engineer.
s long affiliation with the Georgia Power
mpany has included the various duties of
ident engineer on the Tallulah Falls
velopment, rehabilitation of the under-
und distribution system at Atlanta, Ga.,
ctrical engineer, electrical engineer and
rating manager, and, since 1923, assis-
t to the vice-president as well as general
nager, negotiating company relations
h other wire using companies on prob-
ns of inductive interference. Mr. Wills
s been particularly active in the National
ctric Light Association, and has served
many of its committees. He is past-
irman of the A.I.E.E. Section at Atlanta,
., was its delegate to the fourth national
lio convention, and a member of the sub-
nmittee on legislation in 1925. His
er memberships include the Institute of
dio Engineers, the International Associa-
n of Electrical Inspectors, the executive
nmittee of which he served for 2 years;
American Engineering Council, and the
anta Chamber of Commerce. Mr. Wills
s also a consultant with the committee on
oke prevention.

H. L. WILLS

W. S. PETERSON

O. B. BLACKWELL

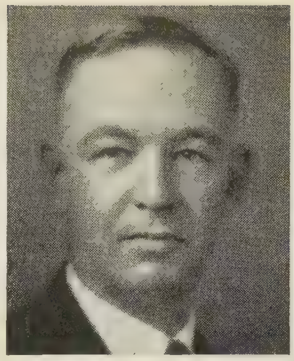
W. S. Peterson (A'23, M'29) trans-
ssion system engineer of the municipal
ter and power department, City of Los
geles, Calif., has been awarded the 1931
.E.E. Pacific District prize for best
per, the decision resting with his paper,
alculation of Dynamic Power Limit of
ansmission System During Three-Phase
ults." Mr Peterson was born at Ana-
nda, Mont. He entered upon an elec-
cal engineering course at the University of
lifornia, Berkeley, Calif., and was gradu-
d with the class of 1917 with his B.S. degree. He at once entered the test department of the General Electric Company at Schenectady, N. Y., remaining there until 1919, when he engaged with the Anaconda Copper Mining Company, Great Falls, Mont., for the operation and maintenance of substations. In September of 1922 Mr. Peterson started his work with the Los Angeles bureau of power and light, and in 1924 was transferred from the drafting room to the substation engineering department, his work including design of substations and writing of specifications. After a year of this work, he was advanced to research. Here his first work was the preparation of a report on the high voltage power system for the City of Los Angeles, which constituted the first step in the design of the system to receive the Colorado River power. Concurrently with this work, he was supervising the investigation of conductor movements during short circuits, the basis of a paper in joint authorship with H. J. McCracken, Jr. (A'27) and for which they received the 1927 national initial paper prize. Mr. Peterson also is serving as secretary of the technical committee of the bureau of power and light of the City of Los Angeles. His research work on the performance of insulators in dust and fog and also with regard to measurement of corona loss were carried on at the H. J. Ryan High Voltage Laboratory at Stanford University, in collaboration with Dr. J. S. Carroll (A'24) assistant professor of electrical engineering at Stanford University, and Bradley Cozzens (A'28) research engineer of the Department of Water and Power, City of Los Angeles.

O. B. Blackwell (A'08, F'17) now transmission development engineer of the American Telephone and Telegraph Company, New York, N. Y., shared in the 1931 A.I.E.E. national prize for best paper in engineering practise, for the paper which he prepared jointly with H. L. Wills (A'30) and which was entitled "Status of Joint Development and Research on Noise Frequency Induction," being an integral part of the symposium on coordination of power and telephone plant to which the prize was awarded.

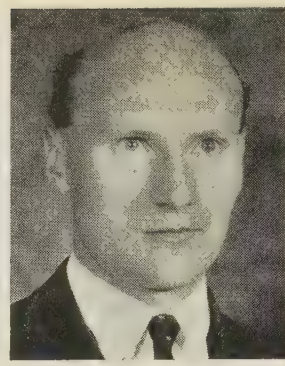
Mr. Blackwell who was born at Bourne, Mass., in 1906 received his B.S. degree from Massachusetts Institute of Technology. He at once entered the engineering department of the American Telephone and Telegraph Company, and in 1915 was placed in charge of transmission and protection, a subdivision of the department. Here he was given the supervision of some 40 technically trained men on important development and standardizing work of telephone transmission and protection circuits. By his collaborators Mr. Blackwell's work always has been recognized as uniformly of the highest grade—in fact it has won recognition for him throughout the entire telephone world. For a period of more than 7 years much of his work was looking toward the extension and betterment of telephone transmission through the use of loading coils, improved cable construction, telephone amplifiers, and similar electrical equipment. Illustrative of his work is the design of a standard transposition system for lines carrying phantom circuits, important work on the development of duplex telephone cables, and contributions of great importance to the successful use of telephone repeaters on long lines. He is a Fellow of the Institute of Radio Engineers and of The Acoustical Society of America; he also holds membership in the Machinery Club of New York City, the Manhassett Bay Yacht Club, and the North Hempstead Country Club.

H. L. Huber (M'23) engineer on foreign wire relations, American Telephone and Telegraph Company, New York, N. Y., who prepared the paper, "Status of Cooperative Work on Joint Use of Poles," in joint authorship with J. C. Martin (A'12) participates in the 1931 A.I.E.E. national prize for best paper in engineering practise, which has been awarded the symposium on coordination of power and telephone plant. Mr. Huber is a native of the state of Colorado, and a graduate of Mercersburg Academy and Cornell University. In 1913 he became plant engineering inspector for The Chesapeake and Potomac Telephone Company, Washington, D. C., designing its outside plant, preparing estimates, writing specifications, and doing construction work. In 1915 he became engineering assistant in the company's general engineering department, checking high tension line construction at crossings, and studying inductive interference and mechanical problems in connection with telephone line construction. In 1917 he was made district plant engineer in charge of laying out the outside telephone plant at Camp Meade and the Aberdeen Proving Grounds. December of that year he joined the U.S.

Signal Corps, and for the last half of 1918 as 1st lieutenant, was locating long distance telephone pole lines in France. In July 1919 he was back in the United States as division plant engineer in West Virginia for The Chesapeake and Potomac Telephone Company, and associated companies in charge of planning, estimating, and writing specifications. The next year he became engineering assistant in the company's general engineering department, which office he continued to hold until 1925 when he was made appraisal engineer. His history with the American Telephone and Telegraph Company dates from 1927.



H. L. HUBER



ERNST WEBER

L. V. BEWLEY

Ernst Weber (A'31) visiting professor of electrical engineering, Polytechnic Institute of Brooklyn, N. Y., has been awarded the 1931 A.I.E.E. national prize for initial paper, for his paper "Field Transients in Magnetic Systems." Doctor Weber was born at Vienna, Austria, and received his diploma as engineer from the Technical University in Vienna, April 1924; 2 years later his Ph.D. was conferred upon him by the same institution. In 1929 he earned what is termed "Privat dozent" (extraordinary professorship) at the Technical University at Berlin-Charlottenburg in the department of electrical engineering. After graduating in 1924 he was research engineer for Oesterreichische Siemens-Schuckert-Werke at Vienna in the department of electrical machine design. He then went with the Siemens-Schuckert-Werke in Berlin as research engineer in the electrical machinery department and continued there until 1930 when he came to the United States. Here he took up his present work at the Polytechnic Institute of Brooklyn in postgraduate lectures on electromagnetic theory, advanced circuit theory, and conformal mapping of high voltage problems. In September of 1931 he was made research professor of electrical engineering, still continuing with postgraduate lecturing, adding "higher mathematical analysis and its application" to his other subjects of discourse.

Doctor Weber is a member of the Viennese Institute of Electrical Engineers (1923); the Berlin Society of Applied Mathematics and Mechanics (1929) and Institute of Electrical Engineers (Germany) (1930). Only recently has become a member of the American Physical Society. He has been an abundant contributor to technical literature both here and abroad.

L. V. Bewley (A'27) of the power transformer department, General Electric Company, Pittsfield, Mass., has been awarded the 1931 A.I.E.E. national prize for best paper in theory and research, for his paper "Transient Oscillations in Distributed Circuits With Special Reference to Transformer Windings." Born at Republic, Wash., Mr. Bewley attended grade and high schools at Boise, Idaho. During the war, he left high school to serve as a machine gunner, spending 19 months out of the 28 he was in service, in France. Upon his return to the United States he entered the University of Washington and in 1923 received his B.S. in E.E. He joined the General Electric Company's test course, its 3-year advanced course in engineering, and the Union College G.E. cooperative course, receiving from the latter in 1927, his M.S. degree. Mr. Bewley's work has included design of induction motors, high-voltage bushings, synchronous converters, a-c. generators and motors, coupling capacitors, and power transformers. For the past few years he has been engaged with special problems of semi-theoretical and mathematical nature, and for the past 6 years in the General Electric evening courses he has taught advanced circuit theory (Maxwell, Heaviside, symmetrical components, system stability, etc.). He has contributed liberally to the Institute's literature, both with regard to technical papers and active discussion. He still holds a captaincy in the U.S. Engineers Reserve Corps.

V. A. Hoover (A'32) has received the 1931 A.I.E.E. Pacific District prize for initial paper, the decision being based upon the high quality of his paper entitled "Correlation of Induction Motor Design Factors." At the present time Mr. Hoover is engaged in the duties of a research assistant at the California Institute of Technology, where he is associated with Dr. S. J. Barnett, professor of physics, in special work on the nature of the elementary magnet in cobalt and nickel alloys. Under Dr. R. W. Sorensen (A'07, F'19) he also has been a teaching fellow in the institution's department of electrical engineering. His Ph.D degree was conferred upon him by California Institute of Technology in 1931 upon the completion of a course in electrical engineering, physics, and mathematics, the culmination of an 8-year period of work, undergraduate and graduate. Mr. Hoover has acquainted himself with the practical side of the profession also by summer work with the Southern California Edison Company, Ltd., at Los Angeles, Calif., where his duties were in connection with substations and meter testing, and by a part-time service with the U. S. Electrical Manufacturing Company of Los Angeles, as motor designer. His native city is Leadville, Colo.

E. W. Palmrose (A'32) who for his paper "Vacuum Tube Voltage Regulators" has received the 1931 A.I.E.E. Pacific District prize for Branch paper, was born in Finland. Upon graduation from the University of California, Berkeley, Calif., May 1931, he received his B.S. in E.E. His first practical work was as an apprentice machinist in the shops of the Hammond Lumber Company, Samoa, Calif.; this occupied him from 1925 to 1928, when after a brief interim he became connected with the Pacific Telephone and Telegraph Company, at Eureka, Calif. His position as draftsman with the Southern Pacific Golden Gate Ferries, Ltd., San Francisco, Calif., dates from late in 1929, on part time until his graduation from the university in May 1931, and full time beginning with June of that year; present activities include repairs to slips and wharves, the design of hydraulic bridge lifting machinery, parts for Diesel engines, steam condensers, and electric steering gear indicators for Diesel-electric ferries. The paper for which Mr. Palmrose was awarded the 1931 A.I.E.E. Pacific District prize for Branch paper was based upon the thesis prepared for his degree of B.S. in E.E.

N. R. Damon (Enrolled Student) University of Colorado, Boulder, Colo., and coauthor of the paper "New Ideas for High Voltage Circuit Breakers" shares with C. A. Church (Enrolled Student) in the award of the 1931 A.I.E.E. North Central District prize for Branch paper. Mr. Damon is a native of Hollenberg, Kans. He received his high school education at Laporte and Cheyenne Wells, Colo., and his technical training at the University of Colorado, from which he was graduated June 1931 with the degree of B.S. in E.E. His work at the present time is in graduate study and research at the University of Colorado, prerequisite to his master's degree in electrical engineering June 1932. Mr. Damon and Mr. Church are also fraternity brothers in Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

J. S. Brown (A'23, M'31) who was formerly engineer in the electrical division of the Stone and Webster Corporation, Boston, Mass., and still earlier identified with engineering projects of the firm of McClellan and Junkersfeld, Inc., and also that of Dwight P. Robinson Company, New York City, in responsible charge as electrical

gineer, assistant superintendent of con-
uction in charge of field forces, and elec-
cal construction superintendent, now
s tentatively entered upon a consulting
gineering practise of his own in electrical
d industrial fields, at Petersburg, Va.

E. B. CRANE (A'23) previously with the
io Edison Company's Youngstown office
assistant engineer, effective June 1, 1932,
s transferred to its central engineering
partment at Akron, a recently created
vision for the coordination and standard-
tion in engineering design, practise, and
terials.

R. H. PARK (A'27), until recently an
ctrical engineer with the Stone and
ebster Engineering Corporation, Boston,
ass., is now affiliated with the Calco
emical Company of Bound Brook, N. J.,
ere he is engaged in research in mathe-
tical physics and the design of equip-
ent. Mr. Park's work with Stone and
ebster included design and operating
oblems in connection with various plant,
ucture, and equipment projects handled
that concern, particularly in connection
th special analyses.

A. E. KENNELLY (A'88, F'13, and past-
esident) professor emeritus of electrical
gineering at Harvard University, Cam-
idge, Mass., on July 6, 1932, at a meeting
Paris, France, was chosen vice-president
the International Electrical Congress
ich convened there July 4–12, and at
ich approximately 1,300 delegates of 11
tions discussed from the angle of pure
ence electrical subjects of the day.

S. P. GRACE (A'03, F'21) assistant vice-
esident of the Bell Telephone Labora-
ries, Inc., recently received from the
iversity of Michigan the honorary degree
Doctor of Engineering, and from Notre
me the honorary degree of Doctor of
ws. (The announcement in ELECTRICAL
GINEERING, July 1932, p. 530, did not
te that the University of Michigan degree
s an honorary degree.)

W. D'A. RYAN (A'02) who has been
ving the General Electric Company of
henectady, N. Y., as director of its
minating engineering laboratory, re-
ntly was named consulting engineer of
company's lighting section.

R. A. KRASOVEC (A'31) whose work during the last several years has been that of chief electrician, U.S. Army Post, Mitchell Field, New York, N. Y.; electrician D. L. & W. Railroad, Hoboken, N. J., and of the New York Central Railroad, Cleveland, Ohio; chief electrician of the Lackawanna Anthracite Coal Mining Company, Vandling, Pa., and from 1929–31, electrical foreman of the Andes Copper Mining Company, Chanaral, Chile, S. A., now has joined the Corte Engineering Company of New York City, as sales engineer.

W. M. WILLIAMS (A'25) who has been serving Roth Brothers Company of Chicago, Ill., as electrical engineer, recently joined the Century Electric Company of St. Louis, Mo.

A. A. SCHUHLER (A'19, M'27) who recently was sales engineer for the Connecticut Telephone and Electric Corporation, at Meriden, Conn., now is chief sales engineer of Stanley and Patterson, Inc., New York, N. Y.

C. E. WHITE (A'30) previously located at Salt Lake City, Utah, and at one time identified with the General Electric Company's general test work on electrical machinery, and with transformer engineering design, now has joined the Ohmite Manufacturing Company of Chicago, Ill., as electrical design and production engineer. Mr. White is past-chairman of the A.I.E.E. Student Branch at the University of Utah, and past-assistant secretary of the Institute's Fort Wayne Section.

W. B. HOPKINS (M'20) who for the past 2 years has served the Stone and Webster Engineering Corporation of New York, N. Y., as a vice-president, engineering manager, and a director, has tendered his resignation, effective June 30, 1932.

C. L. FORTESCUE (A'03, F'21) who is consulting transmission engineer for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and a frequent contributor to A.I.E.E. technical literature, in both papers and discussion, has been chosen by The Franklin Institute to receive the Elliott Cresson Medal, for "his work in presenting theory and application of symmetrical components for studying balanced and unbalanced a-c. circuits," the subject of a paper which he recently presented at a statistical meeting of The Franklin Institute, Philadelphia, Pa.

H. C. FORBES (A'25, M'30) who for the past 5 years has been research engineer in the electrical engineering department of the New York Edison Company, New York, N. Y., recently was appointed system engineer. Mr. Forbes' history with the company dates from 1924 when he joined the electrical engineering department as assistant to the chief electrical engineer.

W. B. CAMPBELL (A'30) who for the past year or so has been serving the Delta Star Electric Company, Chicago, Ill., as assistant engineer, now is assistant curator of motive power at the Museum of Science and Industry in Chicago.

C. W. ADAMS (A'20) formerly manager of the carbon products division of the United States Graphite Company, of Saginaw, Mich., is now with the California Public Service Company, as its division manager at Fort Bragg, Calif.

A. C. BATES (A'31) who was research assistant at Purdue University, West Lafayette, Ind., now is identified with the University of Pennsylvania at Philadelphia, Pa., as instructor in the department of mechanical engineering.

K. W. JARVIS (A'25) who was radio engineer of the United States Radio and Television Corporation, at Marion, Ind., and who has served the Institute of Radio Engineers on several of its committees, now is assistant chief engineer of the Zenith Radio Corporation in Chicago, Ill.

C. F. HIRSHFELD (A'05) chief of Detroit Edison Company's research department and a manager of The American Society of Mechanical Engineers, recently was honored with the degree of Doctor of Engineering by Rensselaer Polytechnic Institute, Troy, N. Y.

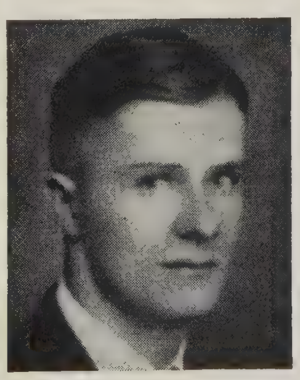
J. L. MCQUARRIE (A'07, F'26) who has been serving the International Telephone and Telegraph Company, New York, N. Y., as a vice-president and chief engineer, has tendered his resignation and will retire from these connections.

GERARD SWOPE (A'99, F'22) president of the General Electric Company, New York, N. Y., was given the degree of Doctor of Science recently by Washington University, at St. Louis, Mo., his native city.

F. A. ROGERS (A'06, M'28) professor of physics and electrical engineering at Lewis Institute of Technology, Chicago, Ill., has been appointed dean of its engineering faculty.

A. J. SMITH (A'22, M'29) who has been serving the General Water Works and Electrical Corporation, New York, N. Y.,

V. A. HOOVER



E. W. PALMROSE

W. R. DAMON

as vice-president now has opened a consulting engineering office in Vancouver, B. C., Can.

C. A. Robinson (A'11, F'22) who prior to becoming assistant vice-president of the Chesapeake and Potomac Telephone Company was its chief engineer, recently was given the new office of general manager. His headquarters will be at Charleston, W. Va. For one year (1926–27) Mr. Robinson was chairman of the Institute's Washington (D. C.) Section, and for 2 years (1927–29) was a member of its communication committee.

Rolf Alvung (A' 25) previously associated with the Standard Steel Car Company, Hammond, Ind., as an electrical engineer, now is with the Chicago Great Western Railroad, Chicago, Ill., in like capacity.

R. A. Connor (A'17) for the past year has been Pacific Coast manager of the National Electric Products, Inca manufacturing division, Los Angeles, Calif.; now he is western manager of the Phelps Dodge Copper Products Corp., Inca manufacturing division, in the same city.

P. de G. Baldwin (A'31) who last year was serving the RCA Photophone Inc., of Philadelphia, Pa., as installation and service engineer now is broadcast engineer of the WALR radio station at Zanesville, Ohio.

Newton Jackson (A'14, M'17) electrical engineer for the Virginia Public Service Company, at Charlottesville, Va., has been transferred to the company's office at Alexandria, Va.

F. I. Lawson (A'22) assistant engineer of the division of hydroelectric and transmission engineering of the Pacific Gas and Electric Company, San Francisco, Calif., recently joined that company's bureau of tests at Emeryville, Calif.

H. H. Cox (A'08, M'27) of the department of water and power, Los Angeles, Calif., has been appointed to the executive committee of the Los Angeles Electric Club for the year 1932–33.

F. J. Bartholomew (A'26) president of Electric Power Equipment, Ltd., Vancouver, B. C., is a director of the Vancouver Electric Club, for the current term of service.

J. D. Ross (A'08, F'12) has recently received his reappointment to the office of superintendent of the city light department, Seattle, Wash., a service which he already has rendered that city over an extended period during consecutive years.

S. E. Doane (A'89, F'12) consulting engineer, New York, N. Y., has received election as a vice-president of A. F. Hatch and Company, Inc., New York, N. Y., a reorganizing and refinancing body for firms in distress.

Obituary

William Wolcott Tefft (M'26) consulting engineer of Jackson, Mich., died on June 24, 1932, at the Doctor Cowie private hospital in Ann Arbor, Mich. Mr. Tefft had for many years been prominent in the power activities of Michigan and surrounding states, and many of the outstanding developments of this region are credited to him. He was born at Milbank, S. D., in 1882, receiving his B.S. in C.E. in 1907 from the University of Michigan; in 1930 he received the honorary degree of doctor of civil engineering from the same institution. In 1910 he married Ethel L. Foote, daughter of W. A. Foote, who with his brother founded the Consumers Power Company. He began his professional career in 1902, spending summers as a rodman with surveying parties in electric railway construction, and later engaged in federal water power surveys until 1906. 1907–8 found him as resident engineer for the construction of a hydroelectric plant at Superior, Mich. His first connection with the Fargo Engineering Company, Jackson, Mich., was in 1908; here he continued as a member of the firm until 1919, having complete supervision of work on a large number of dams, many of them important plants on what is now the system of the Consumers Power Company. During this period he invented the Tefft conduit spillway which is claimed to reduce hydroelectric construction costs in some instances as much as 42 per cent. During the World War he investigated and reported to the government on water power possibilities in Michigan and Wisconsin. Continuing with offices in Jackson, he was consulting hydraulic and civil engineer for Hodenpyl, Hardy and Company between 1919 and 1924, and from this latter date until 1928 was vice-president and chief engineer of the Commonwealth Power Corporation and subsidiary companies, including the Consumers Power Company. In 1928 he entered private practise as a consulting engineer and in 1929 rejoined the Fargo Engineering Company as vice-president, in which office he continued until his death. Since 1930 he has been also president of the General Power Corporation. Mr. Tefft was the author of many technical articles, and a member of the American Society of Civil Engineers, The American Society of Mechanical Engineers, Michigan Engineering Society (director), National Electric Light Association, the American Society of Military Engineers, the American Society for the Advancement of Science, and American Men of Science. He was a member of the American committee to the World Power Conference, and was president of the board of trustees of Albion (Mich.) College. He was honored in 1929 by membership in Sigma Xi "for accomplishments in hydraulic engineering." Mr. Tefft has been active in church work. The clubs of which he was a member include the Rotary, Torch, Jackson City, Jackson Country, Jackson Gun, and the Bras Coupe Hunting and Fishing Clubs.

Robert Baird Williamson (A'02, F'12) for many years in charge of the Allis-Chalmers Manufacturing Company's division on a-c. rotating machinery, at Milwaukee, Wis., died June 26, 1932. Mr. Williamson, who was born at Smith's Falls, Ontario, Can., 59 years ago, was graduated from Cornell University, Ithaca, N. Y., in 1893. Two years of electrical construction work was followed by 2 years as chief draftsman for the Canadian General Electric Company. During the 3 years following 1897, while serving as an instructor in electrical engineering at Lehigh University, Bethlehem, Pa., the textbook "Alternating Currents" was written with Prof. W. S. Franklin as coauthor. This book for a score of years was standard in leading engineering colleges. From 1899 to 1905 Mr. Williamson served as principal of the electrical engineering department of the International Correspondence Schools. In 1905 he joined the Norwood, Ohio, plant of the Allis-Chalmers organization. His manner was quiet and unassuming and one which would inspire confidence immediately. The 27 years during which he was a member of the engineering staff of the Allis-Chalmers Manufacturing Company included a period of great expansion in the electrical industry, marked by the adoption of machinery of ever increasing size; many machines designed under Mr. Williamson's supervision have established world's records for size and efficiency. He has been a frequent contributor to A.I.E.E. literature, has served on the board of managers and as a member of the following technical committees: industrial and domestic power (1916–20); iron and steel industry (1916–20); power stations (1919–24); standards (1916–22); U.S. National committee of the International Electrotechnical Commission (1919–27); Edison Medal (1921–23); electrical machinery (1921–32); and the Lamme Medal committee (1930–32). He also served as the Institute's representative on American Engineering Council (1924–25). Mr. Williamson was a member of the honorary scientific fraternity, Sigma Xi, the Engineers Society of Milwaukee, the University Club, Westmoor Country Club, and a trustee of the Milwaukee Calvary Presbyterian Church.

Basil Condon Battye (M'21) the A.I.E.E.'s local honorary secretary for India with headquarters at Lahore, and chief engineer of the hydroelectric branch of the Punjab Public Works Department, was killed in a motor accident which occurred May 16, 1932, near Batala, district of Gurdaspur, India. Although born in Punjab, Colonel Battye received practically all of his schooling in the various preparatory institutions and colleges of Great Britain; this included a year at the Royal Military Academy at Woolwich, and a year and a half at the School of Military Engineering, at Chatham, England. In 1903 at the age of 21 he became a lieutenant in the 53rd Railway Company of Royal Engineers, the next year advancing to military assistant field engineer. In 1908 still in the English army, but working in a civilian capacity, he took what was termed "specialist training" with various firms in

ngland. Again returning to the strictly ilitary field, he became officiating supervising electrical engineer of the Military Vorks Department, with headquarters at imla, India. Following this he served as eputy assistant director general also at imla military headquarters. From 1910 o 1914 his government loaned him to the 'unjab Public Works Department, where, s engineer-in-charge, he designed, contructed, and operated the Simla hydrolectric and water works extensions. This vork was followed by a tour of Switzerland or the purpose of inspecting all hydrolectric plants of importance in that couny. November 1914 he was in command f the 21st Company, 3rd Sappers and Miners, of the Lahore Division in France; ere he organized the trench searchlight ervice. He was wounded in the early part f 1915, but upon recuperation returned to ction and became field engineer of the ahore Division, later in that same year eing made general staff officer, 3rd to 1st rade. In 1917 he became assistant engieer-in-chief, general headquarters, in harge of the forward transportation deartment; in 1918, chief engineer, G. H. Q. efence scheme; and later that same year, eneral staff officer, 1st grade, 34th Diviion. During the war he was 7 times nentioned in military dispatches to England and in 1916 received the D. S. O. Upon return to civilian life in 1919 he beecame engineer-in-charge of the Sutlej River hydroelectric project, then under nvestigation, with surveys to complete and esign and estimates to prepare. His onnection with the Punjab public works epartment took him out upon many nissions of design and construction. It vas while on a company errand that he was atally injured in a motor crash. He was n associate member of the British Institution of Civil Engineers and the Institution f Electrical Engineers, and also of the American Society of Civil Engineers.

ARCHIBALD JOHNSON ROBERTSON (A'16) ubstation manager for the Mt. Whitney ivision of the Southern California Edison Company, Ltd., at Visalia, Calif., died uddenly June 13, 1932, in that city. Born in Cleveland, Ga., September 19, 876, he spent the period 1894–98 in atendance at Georgia School of Technology t Atlanta. His first commercial work was vith the Fulton Bag and Cotton Mills in hat city; but he remained with these nterests for less than a year and in 1899 oined the Hardy Tyne Manufacturing Company at Birmingham, Ala. Later in he same year he became operator of various ydroelectric plants of the Mt. Whitney Power and Electric Company (subsequently unit of the Edison system). His affiliation vith this company continued unbroken up to the time of his death.

HENRY LYLES ZABRISKIE (A'03) who has een serving the Diehl Manufacturing Company, of Elizabethport, N. J., as chief ngineer, died the evening of July 10, 1932. He was born in New Baltimore, N. Y., anuary 26, 1877; from Cornell University, in 1898, he won his degree of M.E. in E.E. This, however, was 2 years subsequent to his first practical professional work when he served the Excelsior Electric Company of Brooklyn, N. Y., in its drafting and testing departments. For a short period he was with the Fort Wayne Electric Company (Indiana), as assistant to the electrical engineer, and upon leaving this company in 1899, he became assistant electrical engineer for the Siemens and Halske Electric Company, of Chicago, Ill. Here he remained until late in the year 1900, when he joined the New York Transportation Company, New York, N. Y., first in its electrical engineering department, and later becoming treasurer. His record with the Diehl Manufacturing Company covers a period of more than 25 years, always in the office of chief engineer. He was a member of the Institute's electrical machinery committee 1926–27, 1928–31.

RICHMOND TALBOT (A'02 and Life Member) who has been a member of the firm of Sanderson and Porter, an engineering concern of New York City, died at his home in Tuxedo, N. Y., May 26, 1932. He was 59 years of age and a native of New York City. After a primary education obtained in the Cutler private school of New York City, Mr. Talbot attended the Philips Exeter Academy, later graduating from Harvard University with the class of 1896. For about a year thereafter he was associated with the Marsh Plate Glass Company of Pittsburgh, Pa.; then he returned to New York City to become a member of the firm of Sanderson and Porter, at that time active in electric lighting and railway design, construction, and operation; hydraulic development, and transmission. In 1899 in addition to his duties with Sanderson and Porter, he took over the general managership of the Tuxedo Electric Light Company, at Tuxedo, N. Y., his place of residence. In his Sanderson and Porter affiliation he was associated with many important public utility and industrial activities organized and built up by his firm, and with their management and operation. His social clubs included the Union, Racquet and Tennis, New York Yacht, City Midday, Harvard (N. Y.), St. Nicholas Society, Tuxedo, and the Harvard Club of Boston.

FRANK HAYE (A'31) electrical mechanic of the Industrial Electric Motor and Tool Company, Inc., New York, N. Y., died suddenly June 9, 1932, in New York, N. Y., of heart failure. He was born in Tettnang, Germany, March 8, 1903. He attended a trade school, studying electrical engineering, in Munich, becoming an electrical mechanic. From 1917 to 1920 he served an apprenticeship in his native town; then early in 1921 he engaged as mechanic with a firm in Friedrichshafen, Germany. This experience which was of short duration was followed by 2 years as electrician helper for a number of local business interests in Munich, Germany. The first of the year 1923 found him engaged as electrical mechanic for Mittlere Jsar A. G., Munich, where he remained until the fall of 1924 when he became salesman of tools, for commercial interests at Koenigsberg e. P. The following fall he went to Stockholm, Sweden, as electrician for Werdenhoffs Elektriska Aktiebolag, serving in this capacity with this and another firm until March 1927 when he came to the United States and engaged with the company with which he was connected at the time of his death.

Local Meetings

District No. 6 Holds Annual Student Conference

In attendance at the sixth annual conference of student branches held by the Institute's North Central District (No. 6) April 15 and 16, 1932, at the University of Denver, Denver, Colo., were 73 members, delegates and other interested parties, most of whom took part in the many active discussions. Two sessions of the conference were held, one Friday afternoon, and one Saturday morning, both presided over by District Vice-President P. H. Patton of Omaha, Neb. Friday evening, April 15, the delegates to the conference were guests of the Denver Section at dinner, following which Dr. Charles A. Lory, president of the Colorado State Agricultural College, Ft. Collins, addressed the group on the subject of "Rural Electrification," a subject of local and timely interest which aroused extensive discussion. At the Friday afternoon session, the following papers were presented:

DETAILED REPORT ON THE 1931 ANNUAL SUMMER CONVENTION, by H. F. Rice, student counselor, University of North Dakota Branch, and M. S. Coover, secretary District No. 6.

OBSERVATIONS ON THE SUCCESS AND FAILURE OF ENGINEERING GRADUATES, by R. B. Bonney, educational director, Mountain States Telephone and Telegraph Company, Denver, and A. H. Heitzler, superintendent, electric department, Public Service Company of Colorado, Denver (two papers).

THE IMPORTANCE OF A GOOD COMMAND OF ENGLISH IN THE LIFE OF THE ENGINEER, by P. H. Patton, District vice-president.

WHAT SHOULD BE THE PLACE OF THE ENGINEER IN PRESENT DAY LIFE?, by W. C. DuVall, student counselor, University of Colorado Branch.

The Saturday morning session was opened by an address by Dr. W. D. Engle, vice-chancellor of the University of Denver, who voiced the official welcome to the delegates to the conference. Presented at the

Saturday morning session were the following papers.

What Should Be the Place of the Engineer in Present Day Life? by H. S. Rush, student counselor, North Dakota Agricultural College Branch, and W. M. Ely, chairman, University of Nebraska Branch (two papers).

How Can the Branch Aid in Developing Personality and Leadership Among Its Members? by C. W. Caldwell, counselor, University of South Dakota Branch, F. W. Cooper, chairman, University of Colorado Branch, and L. J. Schwehr, chairman, North Dakota Agricultural College Branch (three papers).

How Can the Branch Aid the High School Senior and the College Freshman to Determine His Adaptability for an Engineering Career? by L. C. Trussler, chairman, University of Denver Branch, A. J. Redmann, chairman, University of North Dakota Branch, and H. L. Fry, chairman, South Dakota State School of Mines Branch (three papers).

Should Engineering Schools Modify Their Curricula to Better Meet Present Day Economic Conditions? by G. H. Sechrist, counselor, University of Wyoming Branch, and J. O. Kammerman, counselor, South Dakota State School of Mines Branch (two papers).

To What Extent Should Students Be Urged to Become Members of the A.I.E.E.? by F. W. Norris, counselor, University of Nebraska Branch, L. Johnson, chairman, University of South Dakota Branch, and N. H. Sanders, chairman, University of Wyoming Branch (three papers).

The conference took action on the question of the seventh annual District conference, assigning it to the South Dakota State School of Mines, Rapid City, S. Dak., for the spring of 1933. Conference action also included the election of Prof. H. S. Rush, counselor of the North Dakota Agricultural College Branch, as chairman of the committee on student activities for the North Central District, to succeed Prof. H. F. Rice, counselor of the University of North Dakota. Professor Rush attended the annual summer convention at Cleveland in June 1932 as the counselor delegate from District No. 6.

Analysis of the attendance of the District conference is as follows:

District officers	2
Student counselors	8
Branch chairmen	8
Students, Colo. State Teachers College	3
Students, Univ. of Denver	4
Students, Univ. of Colo.	4
Mountain States Tel. & Tel. Co.	8
Public Service Co. of Colo.	16
General Electric Co.	4
Colo. Agricultural College	2
Univ. of Colo.	3
Univ. of Denver	2
Consulting engineers and others	9
Total	73

Past Section Meetings

Atlanta

Functions of a Public Service Commission, by James A. Perry, Georgia Pub. Serv. Commission. June 6. Att. 230.

Boston

Annual meeting. Election of officers: F. D. Hallock, chmn.; W. H. Timbie, vice-chmn.; G. J. Crowdes, secy.-treas. May 17. Att. 120.

Cincinnati

Joint meeting with the Univ. of Cincinnati Branch. The following papers presented by students: Design and Construction of a Laboratory Arc Furnace, by E. J. Emmerling; Measurement of Modulation, by J. Epstein; Measurement of Radiation, by C. L. Ramsey; Constant Radio Frequency, by A. C. Hereweh. May 12. Att. 140.

Columbus

Astronomy and Human Affairs, by Prof. H. T. Stetson, Ohio Wesleyan Univ. Election of officers: K. Y. Tang, chmn.; Roy Mallory, vice-chmn.; H. L. Willson, secy.-treas. June 3. Att. 30.

Detroit-Ann Arbor

Election of officers: O. E. Hauser, chmn.; J. R. North, vice-chmn.; R. Foulkrod, secy.-treas. Golf and dinner. June 18. Att. 43.

Houston

Election of officers: James B. Arthur, chmn.; P. H. Robinson, secy.-treas. Dinner. May 31. Att. 81.

Ithaca

Teletypewriter Systems, by B. K. Boyce, N. Y. Tel. Co. April 22. Att. 160.

Election of officers: W. E. Meserve, chmn.; B. K. Northrop, secy.-treas. June 3.

Louisville

Business and recreational meeting. Election of officers: C. M. Ewing, chmn.; L. O. Adams, secy.-treas. June 17. Att. 72.

Memphis

Inspection trip through the Memphis Pwr. and Lt. Co. June 21. Att. 55.

Mexico

Outlook of Railroad Electrification in Mexico, by P. Gomez Pena, Natl. Rys. of Mexico. Dinner. June 16. Att. 36.

Minnesota

Annual dinner dance. Election of officers: H. J. Pierce, chmn.; E. H. Hagensick, vice-chmn.; R. R. Herrmann, secy.-treas. June 3. Att. 88.

San Antonio

Organization and Cooperation vs. Individual Ability, by M. C. Johnson, J. C. Penny Co. Dinner. May 28. Att. 57.

San Francisco

Adventures in Science, by Ellis L. Manning, Genl. Elec. Co. Dinner. May 31. Att. 1150.

Sharon

Ultra Violet and Its Application, by G. W. Keown, Westinghouse Lamp Co. Film—"Hydro Electric Power Development in the New South." June 14. Att. 98.

Spokane

History of the Electrical Development of the Inland Empire, by John B. Fisken, Washington Water Pwr. Co. May 26. Att. 14.

Toledo

Research as a Tool of Industry, by Dr. W. E. Wickenden, Case Sch. of Applied Science. April 5. Att. 700.

Problems in Designing of Large Alternating Current Generators, by S. H. Mortensen, Allis-Chalmers Mfg. Co. Illus. April 15. Att. 28.

Application of Electricity in Industry, by Ralph Paxton, Toledo Edison Co. May 20. Att. 30.

Modern Engineering Achievements, by C. L. Proctor, Toledo Edison Co.; Humaneering, by S. K. Mahon, Toledo Edison Co. Election of officers: I. H. Heitkamp, chmn.; E. H. Howell, vice-chmn.; W. M. Campbell, secy.-treas. June 15. Att. 28.

Urbana

Election of officers: E. A. Reid, chmn.; H. N. Hayward, vice-chmn.; L. L. Smith, secy. May 16. Att. 14.

Vancouver

Annual meeting. May 21. Att. 23.

Election of officers: G. R. Wright, chmn.; L. B. Stacey, vice-chmn.; D. M. Johnstone, secy. June 6. Att. 21.

Washington

Cleveland-Emerson Dial Project, by J. A. Remon, Chesapeake & Potomac Tel. Co. Dinner. April 12. Att. 160.

Functions and Operation of Meter Department, by W. H. Fellows, Potomac Elec. Pwr. Co. Election of officers: Prof. T. J. MacKavanagh, chmn.; Roland Whitehurst, vice-chmn.; E. T. Walker, secy.-treas. Dinner. May 10. Att. 75.

Past Branch Meetings

Armour Institute of Technology

Election of officers: H. Rychlick, chmn.; R. Snelling, vice-chmn.; H. Schwennesen, secy.; E. Dumser, treas. June 10. Att. 41.

Carnegie Institute of Technology

Electrical Achievements of 1931, by W. B. Spellmire, Genl. Elec. Co.; Experiences in the General Electric Student Test Course, by H. S. Young, Jr., Genl. Elec. Co. May 27. Att. 39.

Michigan College of Mining and Technology

Election of officers: Jerome Williams, chmn.; Leon Messenger, vice-chmn.; Fredrick Plaga, secy.; Robert Simpkins, treas. June 1. Att. 12.

Milwaukee School of Engineering

Progress of Aviation in the United States, by C. E. Mayhue, Kohler Aviation Corp. Election of officers: Gale Young, chmn.; Wm. Kettenacker, vice-chmn.; Roy Christianson, secy.; Anthony Flout, treas. June 8. Att. 102.

University of Minnesota

Election of officers: Paul Erickson, chmn.; Arvid Turnquist, secy.-treas. May 24. Att. 36.

University of New Hampshire

Election of officers: Roger Hunt, chmn.; Leslie Huse, vice-chmn.; Philip Thomas, secy. April 23. Att. 24.

Thyratron Tubes, by L. A. Barker, student; Characteristics of a Motor With a Centrifugal Pump Directly Connected to the Motor, by P. A. Rolfe, student; An Experiment on Concatenation, by V. T. Swain, student. May 14. Att. 21.

Transformer Harmonics, by H. J. Joyal, student; Electrical Transients, by H. Wood, student; Magnetic Brakes, by B. Booth, student. May 21. Att. 19.

College of the City of New York

Election of officers: John Ragazzini, chmn.; Charles Grossfeld, vice-chmn.; Richard Brill, secy.; G. B. Criss, treas. May 19. Att. 21.

University of North Dakota

Business meeting. May 25.

Pratt Institute

Shot-Gun Fuses, by A. F. Bruder, student. May 26. Att. 20.

Election of officers: Galen Allison, chmn.; Raymond Farrell, vice-chmn.; Allan Tiffany, secy.; George Stringer, treas. May 27. Att. 30.

Stanford University

The Five Year Plan in Relation to Engineering, by P. M. Narbutovskih, student. Election of officers: George W. Dunlap, chmn.; G. E. J. Jamart, vice-chmn.; L. J. Lewis, secy.-treas. June 1.

Texas Technological College

Population Forecast, by Arthur Waghorn presented by J. P. Conner, students. Film—"Speeding Up Our Deep Sea Cables." Election of officers: J. P. Conner, pres.; Walter Cox, vice-pres.; S. A. Cousins, secy.-treas. May 18. Att. 17.

University of Washington

Milwaukee Electrification, by R. Beeuwkes, Chicago, Milwaukee, and St. Paul Ry. Co. May 26. Att. 44.

University of Wisconsin

Calculation of Magnetic Flux Density and Force Between Bus Bars, by W. E. Wyss, student. March 8. Att. 23.

Prospecting in Science, by M. W. Hanks, Hankscraft Co. April 20. Att. 65.

The Use of Models at Short Wave Lengths in Antenna Investigations, by G. H. Brown and R. King, students. Election of officers: W. E. Wyss, chmn.; H. H. Kieckhefer, vice-chmn.; L. A. Leifer, secy.-treas. May 18. Att. 26.

Employment Notes

Of the Engineering Societies Employment Service

Positions Open

EXEC. DESIGNING ENGR. for oil switch division. Must be fully trained E.E. thoroughly experienced in the modern design and construction f high tension overhead equipment, especially oil witches. Must have executive ability and speak erman fluently. Apply by letter stating comlete information as to age, education, experience, eferences, salary, etc. Location, Europe. W-754-CS.

Men Available

onstruction

ASSOC. A.I.E.E., B.S. IN E.E., 33, single, 10 r. experience in construction with contractor, $1^1/_2$ r. instructor in high school, 2 yr. field engr. during survey with utility. C-8633.

GRAD. E.E., 29, 5 yr. supervisory construction, esign, estimating and field engg. experience on uper-power plants and substations; 4 yr. industrial pwr. plant operation, elec. construction and maintenance experience; ry. electrification construction experience. C-4428.

PRACTICAL ELEC. CONSTRUCTION CHIEF, 32, single, 14 yr. experience in construction and also maintenance work. Last 4 yr. in Latin-America. Can speak Spanish and German airly well. Available immediately. Location, mmaterial. C-2101.

esign and Development

GRAD. E.E., M.I.T., 1923, 31, single. Design f steam and hydro gen. stations. Substations, wr. transmission lines and industrial installations. vailable immediately. Location, immaterial.)-1098.

E.E. GRAD., 29, single, 2 yr. additional study n accounting, 2 yr. experience on elec. wiring of ldgs., 5 yrs. experience on elec. and mech. design, evelopment, and lab. work on fans and small notors with leading mfr. Also experience in drafting and commercial engg. New England preferred.)-580.

E.E. GRAD., 29, single, 5 yr. experience includng 6 months testing a-c., d-c. machines, $4^1/_2$ yrs. esign 5 to 2,000 hp. a-c. and d-c. motors for inustrial and special applications. Thoroughly amiliar with motor quotations, estimates and appliations. Desires position with utility, mfg. or contruction firm. Location, U.S. Available imnediately. D-944.

ELEC.-MECH. ENGR., 30, married, college rad. with unusual abilities for elec. relay circuits autom. teleph., control, alarm systems, signaling), esourceful mech. designer on small apparatus, 5 yr. ngg. experience. Available immediately. Location, immaterial. C-8373.

EMPLOYERS—Should you require a designer r operator for elec. transmission and distribution r a pwr. salesman, permit me to qualify. B.S. in E.E. and 7 yr. diversified utility experience. B-709.

xecutives

B.S. AND E.E., 20 yr. experience; test, instrucor 2 yr., line supt., constr. engr. large mining co., lec. engr. lighting and pwr. co.; engr. for utility olding co. Experience covers constr., design staions, substations trans., dist. lines, P.F. correction, ne calculations, economic studies, system planning. Will go anywhere and accept any salary. D-1064.

GRAD. E.E., 1927, single, 26. Experience: 18 nonths cable development, 2 yr. installation and ervice engr. on talking picture theater equip. including foreign service. Additional education 1 r. genl. course economics, etc., Univ. of London. Position desired offering experience with economic roblems or personnel relationships. D-1159.

EXEC. ENGR., Scandinavian, 43, Amer., with 0 yr. experience in design and research of pwr. staions, transmission lines, transformers, and oil circuit reakers, desires position in U.S. or abroad for pwr. r mfg. co. Speaks German and Scandinavian uently and is thoroughly familiar with Amer. and European Mfg. methods. D-1176.

EXEC. ENGR., mech. and elec., 43, Amer., col. grad. Broad experience in designing, bldg. and operating large industrial pwr. plants. Have exceptional qualifications for rapid, thorough and economical engg. of such projects and the ability to obtain maximum value for the entire investment. D-986.

E.E. GRAD., 12 yr. experience in distribution circuit work, design, testing, etc., and having a completed training in law, desires a position for which experience will qualify. D-1177.

DISTRIBUTION ENGR., tech. grad., 30, married, 8 yr. experience in design, construction and operation of rural and urban distribution systems and evaluation of systems. Best of references. Available at once. C-4247.

ELEC. AND MECH. ENGR., 36, exec., 12 yr. experience in design, construction, development, investigations of pwr. projects and systems expansion for utilities and industrials in the states and abroad. Speaks Spanish and Portugese. D-857.

EXEC. ASST. to pres. or vice-pres. of holding or large operating utility. Twenty yr. experience in construction, engg. and operation, transmission, distribution, city and rural substations, pwr. stations, appraisals, rates, right-of-way, interconnections and reports. East preferred, not essential. D-1246.

Instruction

E.E. GRAD., 1929. G. E. test experience including work in radio and vacuum tube engg. dept.; and with all types of elec. machy. Received M.S. June 1932. Desires teaching or engg. opportunity. D-1036.

E.E. GRAD., 25, married, 4 yr. exceptional tech. experience, some very successful teaching experience. Desires position as instructor in E.E. subjects, mathematics or physics with opportunity of taking graduate work. C-4303.

E.E., Bachelors and Professional degrees, have held responsible teaching position in state institution and have had research experience. Location is not a material consideration. B-7263.

MEMBER, B.SC. IN E.E. Experience: lecturer; asst. prof. and prof. in charge of E.E. dept. of prominent univ., followed by practical design, latterly in charge of a-c. design for well-known mfr. of elec. machy. Desires position teaching or one which demands thorough knowledge of motors. D-1213.

Junior Engineers

E.E. GRAD., 1932, Mich. State Col., 23, singl. Desires engg. work, but will consider anything. Experience in drafting and telephone work. Available at once. Location in Middle West preferred, others considered. D-1236.

E.E. GRAD., 1931, single, 24. Special training in radio, sound apparatus, and photoelectric cells. Desires position in the radio or electroacoustical field or teaching opportunity. Location, immaterial. Available immediately. D-1240.

E.E. GRAD., B.S. IN E.E., Univ. of Ill., 1932, 23, single. Ten months long distance telephone test A. T. & T.; 2 months motion picture sound equipment. Familiar with vacuum tubes and their applications. Available at once. Location, immaterial. D-1108.

JUNIOR ENGR., 1932 grad. of a cooperative tech. col. Has had experience with illumination design; radio manufacture and service. Location, immaterial. D-1109.

GRAD. IN E.E., 1932, 21, desires position immediately, strong physique. Will take anything. Location, immaterial. D-1010.

B.S. in E.E., 1932; single. Fourteen months G.E. test between junior and senior yr. Test records available. Excellent scholastic record. Tech. type: developed thesis; 9 contributions presented at A.I.E.E. Good personality and initiative. Location and salary immaterial. D-1127.

1931 GRAD., Cornell Univ. and Pratt Inst. in Brooklyn. Slight experience with vacuum tubes and resistors. Desires work in radio television, communication, or lines allied to that industry. Available on short notice. Location, immaterial. C-5636.

EXPERIENCED 1932 GRAD., 24, single. Vacuum tubes, photoelectric cells, circuits, research, design, and manufacture. Elec. measurements, especially with cathode ray oscillograph. Experienced in application of elec. methods to mech. engg. problems. Full or part time work. Location preferred, vicinity of New York City. Available after Aug. 15. D-616.

B.S. IN E.E., Carnegie Inst. of Tech., 1932, 5 yr. in radio work and repairing household appliances. Salary immaterial at start. Location, immaterial. Available at once. D-1140.

E.E., 22, single, good references; desires work in generation or transmission of elec. pwr. Satisfied with small salary in order to gain knowledge in field. Has had 2 yr. experience as cooperative student in manufacture of motors and generators. Can locate anywhere. D-159.

E.E. GRAD., 1932, 22, married. Experience in solution of distribution network problems. Desires position in any field of engg. with opportunity for advancement. Salary and location, secondary. Good scholastic record. D-1160.

GRAD. E.E., Rensselaer Poly. Inst., 1932, 23, single. One summer's work on relay squad of N. J. Pub. Serv. Desires position in any E.E. field, preferably illuminating. Available at once. D-1158.

E.E. GRAD., 1930, Columbia, 6 yr. course, 25, single, $1^1/_2$ yr. with Paramount Publix Theatre Construction. Knowledge sound and projection equip., drafting, supervision of construction and layout; instruments, foundry, and pattern shop methods. Desires connection, any engg. capacity. Available immediately. Present location, New York but willing to go anywhere. C-7239.

1932 GRAD., E.E., B.S., from Ohio Northern Univ., 23, single and excellent physical condition. Best of character standing and willing to work hard, starting at the bottom and working up. Desires any position that will pay a living wage. Location immaterial and available immediately. D-1167.

E.E. GRAD., 1931, 25 single, cooperative col.; 12 months experience as asst. in production lab. of a battery mfg. concern. Six months experience as a genl. draftsman. Speaking and reading knowledge of German. Desires position with future.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

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MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

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Location and salary secondary. Available immediately. D-534.

GRAD. E.E., 26, single. Two yr. experience in maintenance, test, and distribution with utility. One yr. drafting and mech. design. Two yr. elec. control sales. Available on short notice. Eastern location preferred. C-6445.

E.E. GRAD., Master's deg., V.P.I., '30, 23, married. One summer in relay dept. pwr. co., 1 yr. teach. fellow, 1 yr. teach. elec. in H.S. Six summers certified electrician. Needs engg. position in utility or industrial concern, or instructor in physics, mathematics or E.E. D-1198.

E.E. GRAD., Yale, B.S., Cum Laude, 1931. M.S. in E.E., 1932, 22, single. Desires experience with utility or industrial concern. Available immediately. Location anywhere in U.S. Northeast preferred. D-1212.

RECENT GRAD., B.S. IN E.E., 23, Newark Col. of Engg., cooperative training with Diehl Mfg. Co. Desires opportunity with future in production or sales. Previous experience in organization. Prefers location in New York metropolitan area. Available at once. D-1137.

E.E. GRAD., cooperative course, Drexel Inst., B.S., 1931. M.S., M.I.T., 1932, 23, single. Two yr. experience in plant dept. of Bell Tel. Co. of Pa. Desires engg. or teaching position. Location in East preferred. Available immediately. References upon request. D-1087.

B.E.E., Northeastern Univ., 1932. Experienced in utilities meter and station repair dept. Good references. Available at once. Location, immaterial. D-1211.

E.E. GRAD., 1932, 24, single. B.S. in E.E. from well known engg. school. Good scholastic record. Four yr. mfg. experience includes timekeeping, cost work, maintenance and assembly. Desires position with opportunity for advancement with utility, engg., or mfg. firm. Location preferred, Ohio-Pa. vicinity, but will consider others. D-908.

E.E., married, E.E., M.E. Twenty-two yr. experience, designing, construction pwr. plants, substations, transmission, distribution systems, and industrial plants, three yr. charge purchasing engg. equip., foreign interests. Three yr. exec. experience, charge engg. dept. large utility syndicate. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

1932 GRAD., Univ. of Ala., 21, single, desires position in any engg. field. Languages: English, German, and Polish. Available immediately. Location, immaterial. D-1166.

E.E., grad. 1928, 28, married. 3½ yr. Westinghouse test course. Good experience on motors and control apparatus; also some civil engg. and supervisory experience. Not afraid of responsibility. Desires a position with future. Location, immaterial. C-9568.

E.E. GRAD., 1932, cooperative col. One yr. with Weston Instrument Co. in various dept. 1 yr. genl. maintenance work. Desires position with any mfg. or engg. concern. Location, immaterial. D-1112.

B.S. in E.E. from Worcester Poly. Inst., 1932, 24, single. Desires engg. work of any nature. With construction company for 4 summers. Location, immaterial. Very good references can be furnished. D-1227.

CORNELL E.E. 1932, A.B. 1930, 23, single, communications option, experienced in design and operation of radio and public address equip. One summer in Bell Tel. Lab. Two summers elec. construction on substations and plant additions. Can write clear concise letters and reports. Salary secondary, East preferred. Available October 1. D-1221.

B.S. 1930, E.E. 1931 from Univ. of So. Car., 23, single. Six months experience with South Carolina Pwr. Rate Investigating Committee. Able and willing to do practically any type of engineering work. Available immediately. Location, immaterial. Can give best of recommendations. D-595.

ENG. GRAD., R.P.I., 1932, E.E. Desires position, preferably pwr. or communications. Location, immaterial. Some experience in drafting. Graduation thesis design of central station. D-1245.

Maintenance & Operation

E.E., B.S. in E.E., 1930, Univ. of Idaho, 24, married. Two yr. with Bell Tel. Lab. in trial installation of new circuits and equip., chiefly telephone equip. for broadcast networks and transatlantic communication. Desires work in an industry or utility with opportunity for advancement. Location, U.S.A. Available at once. D-1001.

E.E. GRAD., 1928, Tri-State Col., 27, single, 3½ yr. engg. experience with utility in design, layout, and detailing of pwr. plant, substations and distribution lines. Desires connection in engg. or operating capacity, in steam pwr. plant. Location, immaterial. Now available. D-89.

RADIO ENGR.-OPERATOR. Fifteen yr. commercial experience; last 8 in broadcast stations including 3 yr. with KDKA. Now with station in metropolitan area. Would like connection with small Southern station. Able to design and construct latest type radio equipment, also serve as operator (licensed). D-1237.

TRANSFORMER ENGR., experienced, installation, care, maintenance, design large pwr. transformers. Nineteen yr. with mfg. transformer where work included preparation of instructions for transformer, erection and examination of failures and determining probable cause. Would be valuable to concerns with number of transformers under their supervision in seeing transformers are properly used, attended, operation. Married. B-199.

RY. E. E., 43, specialist on heavy elec. traction installation, practical operation, and maintenance. E.E. grad., 8 yr. with G. E. Co. in testing, engg., and sales work. 12 yr. in installation, operation, and maintenance of electrification of the C.M.St.P.&P. RR. Contributor to tech. magazines on elec. traction subjects. References and other information furnished on request. Available at present. D-1263.

Research

E.E., 1930, with 2 yr. research work, post graduate study and excellent scholastic record, desires tech. work, preferably mathematical. Location, Northeastern U.S. preferred, but will consider others. D-1183.

E.E. GRAD., 23, Sc.M., M.I.T., Harvard 28; Sc.D., M.I.T., June '32; single, 38; 9 yr. practical experience pwr., business and communication engg.; 2 yr. testing course. Recently made valuable contribution to knowledge net work synthesis. Speaks Swedish, English, German. Reading knowledge French. Desires position, well-known organization preferably communication engg. Available July 15. D-747.

GRAD., Yale 1930, B.S. in E.E., Tau Beta Pi, Assoc., Sigma Xi. Test experience, regulators, motors, industrial control, rectifiers, transformers, photoelectric cells, short circuit lab., work's lab. on insulation, and development work, research lab. Desires employment leading to exec. position. New England preferred. D-1192.

GRAD. E.E., Univ. of Toronto, Canada, 1929. Practical transformer construction experience drafting; 6 mo. test course, Can. Westinghouse; 3 yr. with large U.S.A. alloy co. in supervisory capacity on elec. furnace process and plant operation. Location, immaterial. Available immediately. D-1226.

DEVELOPMENT ENGR., 26, single, E.E. and M.S., high scholastic rating, 3 yr. G.E., research, test and field engg., 2 yr. development of pwr. plant equip. for telephone offices. Location, immaterial. Best of references. Available now. D-1219.

B.S. in E.E. and M.A. in Physics, 25. Three yr. experience at leading industrial lab. in research on vacuum tubes and associated circuits. Desires development work on radio, communication or sound equip., research or teaching E.E. and physics. D-1233.

MECH. and E.E.: Development, research. Elec. motor control, hoisting and conveying, mech. and elec. tests of materials, metallurgy, metallography X-ray analysis. C-6994.

Membership

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Aug. 31, 1932.

L. A. Cantin, E. E. Student, Angola, Ind.
Cater, F. L., (Member) W. R. Grace & Co., N. Y. City.
Crooks, C. L., Pub. Serv. Dept., Glendale, Calif.
Frey, J. C., Hatzel & Buehler, Inc., N. Y. City.
Hartong, H. H., 100 Haven Ave., N. Y. City.
Hildebrandt, C. H., N. Y. Central R. R. Co., Weehawken, N. J.
Hobson, L. S., Genl. Elec. Co., Phila., Pa.
Kallenbach, G. K., N. Y. Pwr. & Lt. Corp., Pleasant Valley, N. Y.
Kaul, R. D., Garrison Fire Detecting System Inc., N. Y. City.
Miller, R. D., (Member) The Pacific Tel. & Tel. Co., Portland, Oregon.
Rose, M. C., C. & P. Telephone Co. of B. C., Baltimore, Md.
Schnyder A. P. (Member) c/o Geo. F. Hardy, Construction Engr., N. Y. City.
Schleicher, M., 11 Cottage Place, White Plains, N. Y.
Simm, S. G., c/o Clyde R. Place, Engr., 420 Lexington Ave., N. Y. City.
Sullivan, A. H. (Member) Cincinnati Union Terminal Co., Ohio.
15 Domestic

Foreign

Banton, F. B., (Member) Cia Colombiana de Electricidad, Barranquilla, Colombia, S. A.
Beljavsky, A. G. (Member) North-Caucas Inst. of Energetics, Novocherkassk, U.S.S.R.
Bryant, A., Kenya & Uganda Govts., Nairobi, Kenya Colony, E. Africa.
Chan, S., 33 Wan Tsai Rd., Hong Kong, China.
Gibbes, Gerald B., Government Electricity Department, St. George's, Grenada, B.W.I.
Headland, H., Pub. Wks. Dept., Waitaki Hydro, South Island, N. Z.
Hickey, M. G., Hackbridge Elec. Construction Co., Hersham, Walton-on-Thames, Surrey, Eng.
Sawhney, B., Assoc. Electrical Industries, Lahore India.
Thampan, K. C., Pykara Construction Wks., Glen Morgan P. O., The Nilgiris, So. India.
Verma, R. P., Gaya Engg. & Elec. Pwr. Sup. Co., Ltd., Gaya, India.
10 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Adams, Albert J., 950—18th Ave., Honolulu, T. H.
Aranda, F. Torres, Privada Lago No. 3, Gral Anaya, Mexico City, Mex.
Archbold, Earl J., Box 2641, Birmingham, Ala.
Blugerman, L. N., 227 N. 18th St., Phila., Pa.
Bugg, Vernon, 736 Transp. Bldg., Washington, D. C.
Callen, R. J., Brunswick Recording Lab., 799 7th Ave., N. Y. City.
Diamond, Harvey, Avenida Concepcion 105, Providencia, Santiago de Chile, S. Am.
Handley, Wilbur H., 517 Milbank Rd., Upper Darby, Pa.
Heffter, Juan, Calle Borges 958, Olivos, Arg. Rep., S. Am.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.
Morita, Kadzuo, c/o Chosen Hydro-Elec. Co., Kankyo-Nando, Korea, Japan.
Neander, M., 182 Pravy Bereg Nevy Kv. 51, Leningrad, U.S.S.R.
Olsson, Oscar G., 361 Mulberry St., Williamsport, Pa.
Pearson, Ernest, 209 Brewster Rd., Scarsdale, N. Y.
Scanlon, D. L., KFPW, Ft. Smith, Ark.
Schroeder, G., Krivokolenni Pereulok No. 11–16, Moscow, U.S.S.R.
Schwartz, Carl, 410 Cathedral Pkwy., N. Y. City.
Van Ness, L. G., 2105–6 Sterick Bldg., Memphis, Tenn.
Vere, Fernand, Union Telefonica, Calle Defensa No. 143, Buenos Aires, Arg., S. Am.
Vetri, L., Western Elec. Co., Inc., 100 Central Ave., Kearny, N. J.
Wiley, Walter S., 200 Fackney St., Carmi, Ill.

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during June are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

INTERNATIONAL UNEMPLOYMENT, a study of Fluctuations in Employment and Unemployment in Several Countries, 1910–1930. M. L. Fledderus, ed. Hague, Holland, and New York, International Industrial Relations Institute, 1932. 496 p., 10x7 in., cloth, $2.50.—For the 1931 Social Economic Congress at The Hague various nation's economists were asked to prepare studies on employment fluctuations to picture the recurrence of unemployment during the last 2 decades. The studies presented in this volume factually show conditions in Australia, Canada, China, Germany, France, Great Britain, the United States, and Russia.

LOAD CURVES AND POWER INDEXES IN THE OPERATION OF ELEC. STATIONS. (In Russian.) By A. K. Darmanchev. 1931, Moscow and Leningrad, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatelvstvo. 119 p., 9x6 in., paper, no price given.—According to Mr. Darmanchev, load curves usually are discussed solely in relation to power plant layout. In the present book they are considered from the point of station operation. The theory of load curves is set forth, and ways in which they may be applied described in detail.

METALLURGY. By E. Gregory. London and Glasgow, Blackie & Son, 1932. 284 p., illus., 9x6 in., cloth,, 17s 6d.—With an introduction by an experienced teacher. A simple, interesting account of the manufacture, properties, and uses of the common engg. metals. The metallurgy of ferrous materials fills 2/3 and includes chapters on the constitution of metallic systems, metallography, and heat treatment, alloy steels and stainless steels. Remainder treats of common non-ferrous alloys.

RAMBLING THROUGH SCIENCE. By A. L. De Leeuw. N. Y. & Lond., McGraw-Hill, Whittlesey House, 1932. 320 p., 9x6 in., cloth, $2.50.—Readers without special training in modern chemistry, physics, and astronomy will find satisfac tion in these informal chapters. Mr. De Leeuw writes conversationally, simply, and clearly on light, sound, relativity, time, space, energy, matter, the elements, and other physical and chemical problems, giving an account which every one can understand of recent scientific discoveries.

REWINDING AND CONNECTING A-C. MOTORS. By D. H. Braymer and A. C. Roe. N. Y. & Lond., McGraw-Hill, 1932. 372 p., illus., 9x6 in., cloth, $3.50.—For technically trained men without shop or factory experience, and students. It aims to provide the fundamental principles of induction-motor windings, and shop information on lap and wave windings as used in current standard motors and in those in service for many years. This information based upon practical experience in winding is presented in form suitable for easy use.

ROYAL TECHNICAL COLLEGE JOURNAL, v. 2, Pt. 4, January 1932. Glasgow, Robert Anderson & Sons. p. 571–710, illus., 10x7 in., paper, 10s 6d.—Records research work recently carried out there. Of greatest interest to engineers are the physical properties of steel after plastic and yield-point extension, magnetostriction of cold-drawn wire, aging and tempering duralumin, segregation in steel, production of uniform illumination over large areas, the photoelectric cell, temperature stresses in non-circular drums and circular flat plates, and the performance of wing radiators.

THERMIONIC VACUUM TUBES and Their Applications. By E. V. Appleton. N. Y., E. P. Dutton & Co., 1931. 117 p., 7x4 in., cloth, $1.25.—A compact, accurate account of internal action in modern vacuum tubes and of their behavior when used as amplifiers, rectifiers, or generators of oscillations, written with the needs of students of general physics in mind.

DER INGENIEUR IN DER ELEKTROINDUSTRIE. By R. Salinger. Vienna, H. Martin, 1929. 118 p., 10x6 in., paper, 10 Aust. s.—This book is to assist the young electrical engineer to professional success. It contains much sage advice upon character formation and professional and commercial training, and discusses the qualities and training essential to various branches of the profession.

AMERICAN MACHINISTS' HANDBOOK. By F. H. Colvin and F. A. Stanley. 5 ed. N. Y. & Lond., McGraw-Hill, 1932. 1134 p., charts, tables, 7x4 in., leather, $4.00.—Popular for 24 years in machine shops and drafting rooms as a convienient source of reference on machine shop practise, standards, and materials. The new edition, the first in 6 years, has been revised carefully, obsolete material removed, and new data added.

APPAREILS POUR LE CALCUL MÉCANIQUE DE L'INTÉGRALE DU PRODUIT DE DEUX FONCTIONS. By A. Nessi and L. Nisolle. Paris, Dunod, 1932. 17 p., illus., 11x7 in., 7 frs.—Describes a mechanical integrator invented by the authors to give the integral of the product of 2 functions. The instrument is relatively inexpensive and can be dismantled into parts for other drafting-room purposes. The theory of the integrator is explained and illustrated.

ELECTRIC POWER EQUIPMENT. By J. G. Tarboux. 2 ed. N. Y. & Lond., McGraw-Hill, 1932. 493 p., illus., 9x6 in., cloth, $5.00.—To give the student already familiar with the fundamentals of electrical circuits and machinery a birdseye view of the entire field of electrical power equipment. Starting with a brief survey of power resources, prime movers, and the relation of steam to water power, it discusses loads and load graphs; then takes up generating and switching equipment circuit layouts, transmission lines, distribution systems, substations, and similar topics. The end is a short chapter on the economics of electric service. A new edition enlarged and thoroughly revised.

ELECTRICAL PHENOMENA IN GASES. By K. K. Darrow. Baltimore, Williams & Wilkins Co., 1932. 492 p., illus., 9x6 in., cloth, $8.00.—An important book which will be welcomed by physicists and chemists as a comprehensive up-to-date treatise, with general principles, methods, and experiments set forth clearly and fully. It fills admirably the need of systematic discussion of work in this field, and brings together data heretofore available only in scattered form.

ELEKTRISCHE MASCHINEN, BD. 3. DIE TRANSFORMATOREN. By R. Richter. Berlin, J. Springer, 1932. 321 p., illus., 10x6 in., cloth, 19.50 rm.—A text-book upon the theory and design of transformers, the subject presented concisely yet comprehensively, and emphasizing especially magnetic, electrical, and thermal phenomena. A clear, logical presentation suited to the needs of engineers and students. Includes brief bibliography.

ELEKTRODYNAMIK. (Handbuch der Experimentalphysik, by W. Wien and F. Harms, Bd. 11, Teil 1.) By G. Mie. Leipzig, Akademische Verlagsgesellschaft, 1932. 502 p., illus., 10x7 in., cloth, 45 rm.—A systemtic comprehensive presentation of the methods and apparatus used in the experimental study of electrodynamic phenomena. The magnetic field and the electric current, the dynamic effects of magnetic fields, and electrodynamic fields are discussed.

FIRST PRINCIPLES OF TELEVISION. By A. Dinsdale. N. Y., John Wiley & Sons, 1932. 241 p., illus., 9x6 in., cloth, $3.50.—Not an attempt to describe every system of television that has been tried, but rather to present the principles that have led to present results and to describe the apparatus now in use. After briefly presenting the most outstanding proposals of early workers, attention is confined to the workers who have gone farthest—Jenkins, Baird and the Bell Telephone Laboratories. These systems are described in considerable detail. In conclusion, the present state of television in Germany, England, and America is discussed.

FIXED NITROGEN. (American Chemical Society, Monograph Series No. 59.) Ed. by H. A. Curtis. N. Y., Chem. Cat. Co., 1932. 517 p., illus., 9x6 in., cloth, $12.00.—The product of a dozen authors, all past or present members of the Fixed Nitrogen Research Laboratory staff at Washington. The main theme is exposition of scientific facts and theories of nitrogen fixation, and of the essentials of commercial processes to obtain and elaborate nitrogen compounds. An extensive bibliography is given.

GENERAL TEXT ON AERONAUTICS. By H. F. Lusk. N. Y., Ronald Press Co., 1932. 420 p., illus., 8x5 in., cloth, $3.25.—Presenting fundamentals of aeronautics in form suitable for use in technical institutes, junior colleges, and aviation ground schools where students are in training for positions in the aviation industry. The principles of flight, construction of airplanes and engines, instruments used, piloting, meteorology, etc., are discussed in elementary fashion. A good introductory course covering information which the Department of Commerce expects airplane pilots to learn in ground schools.

HISTORY OF EXPERIMENTAL PHYSICS. By C. T. Chase. N. Y., D. Van Nostrand Co., 1932. 195 p., illus., 9x6 in., cloth, $2.25.—The book is devoted to the development of physics as an experimental science from the days of Galileo. Attention is directed to history making, researches, and reasons given as to why these are of interest. Present developments are clearly described non-mathematically. The book supplies an interesting account of the gradual advance in this field.

INTERNATIONAL TRADERS' HANDBOOK, incorporating foreign and domestic weights, measures, and moneys. Phila., Commercial Museum, 1932. 175 p., illus., 9x6 in., paper, $1.50.—Useful as desk book for manufacturers engaged in trade with foreign countries, presenting in brief convenient tables, the essential facts concerning trade centers and ports, language, transportation facilities, regulations governing freight and parcel post shipments, weights and measures, and conversion of moneys.

ORTSKURVEN DER STARKSTROMTECHNIK. By G. Hauffe. Berlin, J. Springer, 1932. 174 p., 10x6 in., cloth, 15.50 rm.—Here the method of complex quantities is systematically applied to the theory of locus curves, the book opening with a brief description of the method, followed by a concise summary of the necessary basic laws of electrical engineering. The application of the theory is illustrated by problems connected with oscillating circuits, air-core transformers, three-phase induction motors, and a-c. commutator motors. It closes with a systematic presentation of the general laws of the theory.

OUTLOOK FOR TELEVISION. By O. E. Dunlap. N. Y. & Lond., Harper & Brothers, 1932. 297 p., illus., 10x6 in., cloth, $4.00.—A book "to reveal the romance of television and its commercial possibilities; to record historically the evolution of a new era in radio science; and to explain its magic." The development of all important advances is traced chronologically and the various electrical systems, devices, and ideas used in the search for television are noted. Intended for the general reader, with the subject treated in a popular, non-technical style.

POTENTIALFELDER DER ELEKTROTECHNIK. By F. Ollendorff. Berlin, J. Springer, 1932. 395 p., 10x6 in., cloth, 32 rm.—A systematic course on the subject, intended to facilitate the solution of practical problems in electrical engineering. The opening chapters briefly summarize physical principles, after which the construction of potential fields is discussed at length. The latter half of the book considers boundary problems. Represents the course given at the Berlin Technical High School.

QUANTITATIVE ANALYSIS. By E. G. Mahin. 4 ed. N. Y. & Lond., McGraw-Hill, 1932. 623 p., illus., 8x6 in., cloth, $4.00.—A popular text-book to provide a theoretical and practical discussion to meet the needs of college students. Emphasis is placed upon the scientific principles that form the basis of practical methods of analysis. The book discusses the general processes, the special measurements used in laboratories, and the analysis of the common industrial products and raw materials. This edition has been revised throughout.

Engineering Societies Library

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Industrial Notes

The Okonite Company Promotes Officers.—According to a recent announcement, H. Durant Cheever, former president of the Okonite Company, has been made chairman of the Board, while the position of president is now occupied by Frank Cazenove Jones. Mr. Jones was formerly vice-president and general manager of the company, while in the new position he holds the title of president and general manager. Both men have long been members of the Okonite organization, Mr. Cheever's connection dating back for 44 years. Mr. Jones, who is also chairman of the Power Cable Group of NEMA, joined the Okonite Company after the war. His father, F. C. Jones, was manager of the Okonite factories.

Hubbard & Co. to Manufacture Ohio Brass Line Hardware.—The Ohio Brass Company, Mansfield, Ohio, announces that it has disposed of its line of wood cross-arm hardware, wood guy-strain insulators and steel insulator pins to Hubbard and Company, Pittsburgh, Pa. The latter company is licensed to manufacture and sell pole line hardware developed by Ohio Brass and protected by its patents. This is a manufacturing and sales arrangement only, and there is no financial interest of either company in the other. These materials, in the future, will be manufactured only by Hubbard and Company, although both companies will cooperate in the sale of the devices. Future development work on this class of materials also will be carried forward by both companies. Due to the specialized manufacture and engineering of similar materials by Hubbard, both companies expect that users will benefit by this cooperative arrangement.

Large Clock Contract to Warren Telechron Company.—Contracts for 2,650 synchronous electric clocks for three new government buildings were awarded the latter part of July to the Warren Telechron Company, Ashland, Mass. Approximately 1,100 clocks will be installed in the Department of Justice building, 1,100 in the Interstate Commerce Commission and Labor Department building, and 450 in the Post Office Department building. The recent installation of 875 Telechron clocks in the Internal Revenue building is one of the largest clock systems in the world.

Special Electrical Machine for College Laboratories.—It is sometimes difficult for students of electrical engineering to understand the relationship between direct and alternating-current rotating machines. If these relationships may be studied in a single machine, the connections being changed for the different conditions, it is easier for the student to visualize the actual operation. The Electric Specialty Co., of Stamford, Conn., therefore, has developed a machine which enables the student of electrical engineering to study the operation of the direct-current motor with and without commutating poles, the direct-current generator also with and without commutating poles, rotary converters operating from direct current to alternating current, or from alternating current to direct current, a-c. generators, and a-c. synchronous motors. The single machine may be used to illustrate the operation of all these types. Such a machine may also be equipped with exploring brushes for measuring the voltage between adjacent commutator bars in any position while in operation. A single conductor is also installed through one of the armature slots with each end terminating on a slip-ring fitted with brushes. This development has been completed for machines normally rated from about 3500 to 7500 volt-amperes as rotary converters. Machines of this size are about as small as could be used in order to obtain satisfactory results on all the different types of machines, and also are not so large as to involve too much expense in operation.

New Time Switch.—R. W. Cramer & Co., Inc., 67 Irving Pl., New York, announces a new type of Sauter synchronous motor time switch, gear operated. The new switch contains a self-starting, 200 r.p.m. sub-synchronous motor constructed to assure accurate time keeping on systems where controlled frequency is used. It can be had with either astronomic dial to automatically operate the switch in step with local sunset and sunrise throughout the year, or a plain dial to control either one or two complete operations in twenty-four hours. This switch is recommended by the manufacturer for use on alternating current circuits with regulated frequency.

Trade Literature

Overhead A-C. Network System.—Bulletin C 1944, 8 pp. Describes the new application of economical secondary low voltage networks to low density load areas fed by overhead lines. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Induction Motors.—Bulletin 112, 4 pp. Describes Reliance fully enclosed, fan cooled induction motors, type AA, form F. Reliance Electric & Engg. Co., Ivanhoe Rd., Cleveland, O.

Stainless Steel Motor.—Bulletin, 4 pp. Describes "Linc-Weld" type "E" induction motor, totally enclosed, fan cooled, for use in dust or fume-laden atmospheres. The Lincoln Electric Company, Cleveland, O.

Temperature Measurements in Electrical Apparatus.—Bulletin 871, 28 pp. Describes the method and instruments employed in measuring temperatures in generators, transformers, and cable systems. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

Squirrel Cage Motors.—Bulletin 174, Part 5, 6 pp. Describes Wagner multi-speed squirrel-cage motors. Installation photographs are included as well as outlines of the problems involved in connection with each application. The description covers constant-torque, constant-horsepower and variable-torque motors, further classified as two-speed, three-speed, and four-speed motors. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.

Electrical Tape.—Pocket Bulletin, 16 pp. Describes a combination rubber tape and friction tape. The tape is made of fabric, completely imbedded in a unique rubber compound, and with a degree of adhesion and insulating value claimed to be far higher than ordinary tapes of this character. B. F. Goodrich Company, Akron, O.

Copper Wire and Coils.—Data sheets bound in loose leaf cover and convenient for ready reference. These bulletins are said to be the most complete and authoritative published up to this time on the subject. Inca Mfg. Div., Phelps-Dodge Copper Products Corp., Ft. Wayne, Ind.

Cedar Poles.—Pocket Bulletin, 100 pp., "Handibook of Cedar Pole Specifications." All available data on cedar poles is brought up-to-date in this new publication, featuring the new American Standards Association specifications for both western red and northern white cedar poles, and the new Western Red Cedar Association treating specifications. To facilitate handy reference to the old pole specifications, these are also included. MacGillis & Gibbs Co., 324 East Wisconsin Ave., Milwaukee, Wis.

Oil Filled Cables.—Bulletin. The Okonite-Callender Cable Company, Inc., a subsidiary of the Okonite Company outlines its new activity in manufacturing oil-filled, paper insulated cables. The company's factory at Paterson, N. J., is devoted to the production of impregnated paper-insulated cables of all types. In addition to its regular business of manufacturing the "solid" type of paper-insulated cables, its laboratory and plant have also been fully equipped for making cables of the oil-filled type. The pamphlet points out research and operating developments in extra-high voltage power transmission which have led to the application of oil-filled cables for certain conditions of use. In many underground plants, the growing needs for high operating voltages or for large conductors, without increasing the overall sizes of cables, have become important problems. As some power companies already have costly conduit systems which could not be enlarged or replaced without excessive cost, the application of the oil-filled cables may often present a feasible means of taking care of such conditions. The relative operating characteristics of the solid and oil-filled types are discussed in the bulletin and the subject matter should be interesting where such problems are existing, or where reviews of plant conditions indicate the need of revamping in the future.